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CIVIL ENGINEERING.

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The Sewerage of Algiers. By M. PIARRON DE MONDESIR, *Ing. des Ponts et Chaussées.*

(Continued from page 155.)

Branch Bab-Azoun.—But the longest and most important work, the construction of the branch Bab-Azoun, remained to be done.

This was commenced in May, 1853. I have said that its length was 4943 ft., and that its basin contained a surface of 279 acres.

The point of departure (Pl. II, Fig. 3,) being established at a height of 52·48, and the point where it meets the sea being 0·00, the mean slope of the branch Bab-Azoun is some 0·01 ft. per foot.* But this branch has the following slopes:

For the first	492 feet, . . .	·0167	ft. per foot.
" next	3972 " . . .	·009875	ft. "
" last	459 " . . .	·005	ft. "

It also has three inclines, amounting in all to 2·78 ft.

There were two reasons for not adopting a uniform slope, which, otherwise, would have been most advantageous. 1st. The street Bab-Azoun has a counter slope at the right of Scipio street, and it became necessary to increase the slope in the first 492 feet, to obtain at the lowest points of the counter slope, a height strictly sufficient for the passage of the sewer. 2d. Between Scipio street and the sea, nothing

* All the heights on the profiles are above the mean level of the Mediterranean at Algiers. It is found from observations that there is a difference of 2·12 ft. between the highest and lowest seas. The mean level is set at 1·06 above the lowest level.

forbade the application of the uniform slope, and it was so adjudged in the project. But, in the course of execution, and with a view to increase the discharge of the branch Bab-Azoun and to suppress the wiers, of which mention will be made hereafter, the Administration substituted two slopes and three inclines. I will soon explain how we arrived at an increase in the delivery of the branch.

Before going farther, I give the sections assigned to the branch Bab-Azoun.

These sections were five in number, with widths successively of 3·9 ft., 4·9 ft., 5·9 ft., 6·2 ft., and 6·56 ft.

The height of the side walls being constant and equal for all sections, the height under the key was successively equal to 5·24 ft., 5·75 ft., 6·23 ft., 6·39 ft., and 6·56 ft.

On calculating afterwards the maximum quantity of water falling in a given time upon the surface of 279·1 acres, forming the basin of the branch Bab-Azoun, (a quantity fixed at ·16 ft. per hour, thus leading a supply to the sewer of 554·4 cubic feet per second,) we had sections nearly double, and consequently a considerable increase in the expense of construction. Instead of increasing the sections, a preference was given in the project to the establishment of wiers, to deliver at the level of the springing line of the arches, by means of existing discharge canals, the eventual waste water of the branch Bab-Azoun, which, without this precaution, might submerge the cast iron tubes placed precisely at that level.

This disposition, approved in principle, could give no inconvenience to the port, which would only be exposed to the accidental reception of water, differing but little from the rain water.

The local administration, still desirous of suppressing these wiers, adopted a modification already made known in the account of the slopes.

It was completed by an enlargement of the lower portion upon the 479 feet corresponding to the reduced slope, ·005 ft. per foot; an enlargement which now has a width of 13·1 feet, instead of 6·56 feet. In all other cases, the widths contemplated in the project have been maintained.

The modification spoken of, thus consisted of the lowering the sewer by means of three inclined planes, whose maximum height was 2·78 feet, and of the enlargement of the lower part, whose slope was of necessity reduced by the use of the inclined planes. The delivery of the branch Bab-Azoun is found to be more than doubled by the simple fact of the enlargement of the lower part. Still, the administration decided to preserve the wiers as a precautionary measure, but giving to them a less overfall than originally contemplated in the project.

Wiers and Discharge.—There are three wiers placed opposite the outlet of the three *ravine sewers* of the rampart Poudriere and Tivoli.

I make use of the term *ravine sewer* to designate that whose lower part only is arched, and the upper part open. Thus, these affluents bringing down in freshets stones, gravel, earth, and other solid bodies, do not enter the sewer of the enclosure except through large gratings. A chamber for the alluvium is placed above the grate.

The peculiar disposition adopted for the ravine of Tivoli penetrates the enclosure sewer through an inclined grate placed at the summit of a cesspit. The alluvium chamber is 6·5 feet deep when it is filled; the ravine water being no longer able to penetrate the sewer, will escape through the development of the ancient sewer of Tivoli, which thus becomes a discharging canal.

Such are the measures adopted to insure at all times the passage of the water of the branch Bab-Azoun.

On examining the longitudinal profile of the branch Bab-Azoun, we observe, that while the sewer descends to the sea with nearly a uniform slope, the level of the streets under which it is situated continues nearly the same.

It follows that starting from Scipio street, the lowest point in the street Bab-Azoun, the depth of the sewer below the surface constantly increases.

Opposite the confluence of the ravine sewer of the Bab-Azoun rampart, at the site of the Theatre, the depth of the excavation exceeds 26 feet.

Thus the sewer was executed under ground from this point to the sea, for a length of 3660 feet.

The branch Bab-Azoun is composed of two distinct parts: the upper constructed in an open cut under the street Bab-Azoun, and the lower part tunneled under the street of the Faubourg Bab-Azoun.

There are five common man-holes in the upper part, and nine well man-holes in the tunneled portion; or, in other words, nine vertical openings which served as shafts for removing the excavation of the tunnel, and were so disposed as to answer for approaches to the sewer. There were twenty-eight water-inlets under the pavements.

The total length of secondary sewers is 2361 feet. The sewer communicates in its course with sixty-five private drains, twenty-three gutters, and seventeen public urinals.

The two portions of the Bab-Azoun branch were worked simultaneously in May, 1853.

The portion with an open cut.—The portion in open cut, following upwards the right hand side of the street Bab-Azoun, was built without serious accidents as far as the end of the arcades. The same precautions were taken, and the same measures adopted, as for the street Bab-el-Oued, and for that of the Marine. None of the houses were damaged, though the excavations attained a depth of 18·7 feet.

Under the site of the Theatre between the extremity of the arcades of the street Bab-Azoun and the man-hole, T 5, were found the ancient *silos*,* which it was found necessary to shore up, and consolidate with special masonry.

Subterranean portion.—The main work consisted in the excavation of the underground part. To expedite the work, they commenced simultaneously sinking twelve shafts, ranged at nearly equal distances along the line. These twelve pits, of which the last two near the sea

* *Silos* are cavities without arches presenting a vertical opening, very narrow. These underground pits served the Arabs for the storage of corn.

have been suppressed and filled up, and of which the nine intermediates between them and the man-hole T 5, have been converted into man-hole pits, were sunk to the level of the principal sewer.

The deepest was the shaft T 15, one of the two suppressed; it had a depth of 69 feet. The miners at the bottom of each pit working in opposite directions, the tunnel was thus worked on twenty-four faces, including that of the sea.

Each gang of miners had as a mean 164 feet of gallery to pierce before a junction with the adjoining one. The excavation was in a schistose rock unfavorably bedded, and much riddled with filtrations.

In the early part of July, 1853, the galleries not being connected, the workmen began to suffer much. The air in the galleries was not renewed, the heat was oppressive, the smell of the lamps and the fume of the blasts having no sufficient outlet, occasioned asphyxia. As the galleries advanced the filtrations increased, and necessitated night and day work. The miners had their feet in water, and at every instant the filtering water fell in cold drops upon their naked and sweating shoulders. With all these troubles there was no stoppage, and the work went on briskly night and day. The position of the workmen was bettered as far as possible by establishing a current of air by means of wind-sails, a simple method borrowed from the navy. Boots were given to the miners to protect their feet, and oil-cloth sacks for guarding against filtrations.

These inconveniences disappeared mostly towards the close of 1853, on successive intercommunication of the galleries being made. Then the filtering water was drained into the sea.

The most important of these filtrations was found in shaft T 10, (Pl. II, Fig. 3,) under the roots of the beautiful palm, which may be seen at the Faubourg Bab-Azoun, at the foot of the Rampe Bugeaud. This fact explains the superb vegetation and excellent preservation of this tree, which without any care prospers in a dry region.

This water became so annoying to the works that it was decided to pierce a gallery 131 feet long, under Faubourg street, and through it turn the water into the sea, and so get rid of it without the expense of drainage. This gallery will be maintained, and will serve for the running of the source of the palm water, which now passes under the flooring of the sewer, in culverts made for that purpose, and will ultimately feed a public fountain upon the new quays. The conjecture held in the project as to the nature of the rock, where it was supposed that a portion of it might answer for revetment, especially for the side walls, proved to be altogether too favorable. In the course of the execution of the project, it was found that we could not dispense with walling the gallery throughout. The thickness of the side walls was fixed at 1·15 ft., and that of the arches 0·82 ft. in one row of bricks. But these dimensions were considerably exceeded in the execution of the work.

To give an idea of the miscalculations and enlargements which attend the execution of certain tunnels, I believe it would be useful to give some details upon this matter.

A careful comparison of the sections of the galleries has been made to ascertain the exact quantity of rock excavated, as well as the excess of the masonry over the proposed thickness of the revetments. The quantity of excavation exceeds by 785 cubic yards the amount answering to the proposed thickness of the revetment, increased by an allowance of 0·196 ft. in all the circumference accorded by the specifications; this answers to an increase of a little over a cubic yard, per running yard, or, say about one-seventh. This increase, independent of that produced by two great land-slides, of which mention will be shortly made, arose from the unfavorable bedding of the rock, from the presence of small layers of clay in their crevices, from the abundance of filtrations, and from the concussion of the miners hammers. The holes and cavities thus formed, had to be replaced by masonry.

Principal Land-slides.—Two great land-slides occurred in the progress of the tunnel, forming funnel-shaped cavities extending from the bottom of the gallery to the natural surface. The first broke out at the corner of a street upon the public square, near the shaft T 9, in consequence of the rain. The funnel was 33 ft. deep, with nearly an equal diameter at the natural surface. A portion of the pavement was precipitated to the bottom, and the neighboring house was endangered. Fortunately none of the laborers were injured. This sudden slide was all the more unexpected, from the fact that well man-hole, T 9, and the neighboring gallery, had, for more than a year, stood perfectly without revetment or indication of the least movement. It was afterwards discovered that the cause of the accident was due to the presence of an ancient well (which had been filled up) lying immediately above the tunnel, but whose bottom did not reach quite to the top of the gallery. This well, whose existence was not suspected, had, by the influence of the rain, burst through at the bottom, carrying with it the neighboring parts. This accident was promptly repaired without any injurious consequences. They were, however, compelled to locate the pit man-hole some yards above in undisturbed soil.

The second land-slide, and the most considerable, occurred near the fort Bab-Azoun, at the 13·12 ft. section. At this point, on the left hand side of the gallery and near the level of the springing line, was met a layer of clay very much inclined towards the fort Bab-Azoun, which passed under the foundations of this work. The rock was not long laid upon this clay, when it began to slide. Land-slides occurred every day, notwithstanding the shoring, and so left large hollows.

Unfortunately this was in the rainy season, and notwithstanding the great exertions made at this point, when only a few days were needed to make this dangerous passage, the hollow broke in from the top, and a large funnel, 39 ft. diameter and 42·5 ft. deep, was formed by the sliding of the neighboring parts. All the earth above the clay layer slid, and shattered the streets. The foundations of fort Bab-Azoun were uncovered and were suspended without support for several yards distance. The slide occurred in broad day, but fortunately the workmen, forewarned by certain signals, withdrew, leaving their tools behind them. One only was slightly bruised. There remained a space

from 23 to 26 ft. to be constructed at the bottom of this funnel. The masonry was finished above and below this space.

After filling all the unstable parts, on the demands of the military engineers, the foundations of the fort were strutted with strong beams 39 ft. long. After having propped this part, and placing the workmen under the shelter of a platform resting on the streets, the work of closing this dangerous spot was begun. Fair weather favored the operation, which terminated without mishap.

The works of the branch Bab-Azoun were completed in August, 1855. Commenced in May, 1853, and continued without interruption, the work lasted twenty-seven months. About a year before its completion, the upper portion as far as the ravine Poudriere was finished and put in service. The water was delivered, for the time, through the Poudriere sewer which meets the enclosure sewer at the same level. The lower part, between the Poudriere ravine and the sea, was finished without permitting the entrance of a single affluent sewer. All the connexions were made, but the affluents continued to follow their ancient courses. The removal of some provisional dams sufficed for leading their water into the enclosure sewer. By these precautions, all the lower part of the Bab-Azoun, for a length of 2624 ft., was clear of all impurities up to the time of its completion. In the axis of the bottom there was only running a stream of clear water, proceeding from the filtrations which found their way through outlets made in the side walls.

M. the Marshal Count Raudon, Governor-General, to whom Algiers is chiefly indebted for the benefits of this sewer, took advantage of the occasion to visit the great galleries, before they were put in service. A great number of people were enabled to gratify their curiosity, and to pass through the brilliantly illuminated galleries. This official visit in the interior of a sewer is, probably, the only instance of its kind.

Tram Railroad in the branch Bab-Azoun.—The reduction to 0·005 ft. per foot of slope in the branch Bab-Azoun, in the 479 ft., necessarily had the effect of arresting the alluvium brought down by the water. Thus, notwithstanding the proposed system of flushing, a small tram railroad was established upon a causeway of masonry, occupying the right part of the section of 13·12 ft. Experience has already demonstrated the utility of this railroad, which transports directly to the sea the deposits which otherwise must have been carried by barrows, or taken by manual labor through the man-hole pit, T 14, situated 885 ft. from the lower end. (It will be borne in mind that the two shafts, T 15, and T 16, were suppressed, since they were comprised within the accessory works of the fortifications.) The tram railroad, (Plate I, Fig. 8,) has a length of 482 ft. It is prolonged 69 ft. beyond the outlet so as to admit of the wagons being emptied in the deep sea. The causeway of masonry supporting the railway is 4·27 ft. wide; at the origin the causeway is 1·67 ft. above the axis of the invert, and at the lower end it is 0·62 ft., thus giving to the rail track a slope of 0·0075 ft. per foot. The width of the track is 2·43 ft. Two wagons emptying

at the sides do all that is required. They are suspended from the key of the arch, so as not to be carried away in times of freshets.

Materials used in Construction.—All the masonry used in the enclosure sewer and secondary canals was laid in hydraulic mortar of Italian puzzolano. This mortar, composed of equal parts of excellent fat lime of Algiers, of coarse sand, and of puzzolano of Civita Vecchia, and mixed into a somewhat stiff paste by the shovel and hoe, set quite firmly in from six to eight days.

The upper portion of the invert was covered with spalls and a lining of Vassy cement, presenting, united, a thickness of 0·16 ft. The lower part of the side walls, for a height of 0·65 ft., is lined with this cement, a thickness of 0·065 ft. The remainder of the side walls is coated most carefully with hydraulic mortar. The arches are pointed. Cut stone was used at all the points where the fall of water would injure common masonry. Thus the affluents emptying into the sewer let fall their waters upon cut stone work. The flooring of water inlets, particularly exposed to the shock of rain water, is likewise paved with stone masonry.

Ventilation of the Sewer.—It was essential to spare no pains for the ventilation of the galleries. This is now effected by the water inlet grates, by private drains, by terrace gutters, by the public urinals, and, finally, by the openings of the man-holes. Every canal and every pipe acts as a chimney draft for the gas. The gutters were also disposed so as to produce the best effect.

In speaking of flushing, I will point out another effective mode of ventilation which can easily be applied to the enclosure sewers.

Water Inlets.—On the other hand, the water inlet grates, placed in the axis of the kennels, would, in hot weather, present an inconvenience which we have attempted to remedy.

There are three systems of water inlets used upon the sewer: 1st, the hydraulic system; 2d, the valve system; 3d, the system of grates and movable covers.

The hydraulic system can only succeed with the condition that the reserve liquid stationed in the chamber to cut off the gas should be frequently renewed, and that the chamber should not be constantly choked up with deposit. In Algiers, where the streets are Macadamized, the hydraulic water inlets would soon be choked, especially in winter. On the other hand, in summer there are scarcely any currents of water in the kennels except in the neighborhood of the public fountains. It follows then that the reserve liquid of the chambers would itself give forth an odor quite as offensive as that of the sewer.

Thus, I do not hesitate to say that this system which seems to succeed so well in London and to give so much satisfaction there, is not adapted to the climate of Algiers.

As yet, there has been established upon the enclosure sewer, the branch of the Marine, but a single trap water inlet, as a matter of experiment. (Pl. I, Fig. 10.)

The valve system, which has also been experimented on in the sewer, succeeds far better. The valve allows the water and the deposits to

enter without an escape of the gas. It is essential to give a sharp curve to the bottom of the water inlet. This system is, however, liable to derangement. The rust so quickly produced under such conditions, sooner or later prevents the play of the hinges, and the water inlet becomes completely obstructed.

A third system has been applied to the sewer, which consists in disposing the frame of the water inlet, so as to receive at will either a grate or a cast iron cover with a hole in its centre. In winter, when it rains frequently and the inconvenience of the gas is much diminished, the movable grates are placed; but in summer they use the covers. The hole suffices for the flowage of the kennels. If by chance a sudden rain storm should occur in summer (a quite unusual thing in Algiers), the gutter-men in charge could readily raise the covers until the end of the storm.

The system of grates and movable covers which is generally applied to the enclosure sewer, had already existed for several years upon the other sewers of Algiers. They are attended with some inconvenience, but the sum of the advantages unquestionably outweighs it.

Private sewers.—For the junction with private sewers certain precautions were indispensable. It was first necessary that the government should compel the proprietors whose canals already branched into the ancient sewers emptying into the harbor, to make new branches into the enclosure sewer or its affluents. For this purpose, a decree was made by the Mayor of Algiers, dated 12th October, 1852, whose purport was:

ART. 1. According with the advancement of the sewer works of Algiers, the proprietors or principal local tenants of the houses situated in the streets Bab-Azoun, Faubourg Bab-el-Oued, Marine, at the Government square, Mahon, and other streets or squares adjoining, whose conduits empty directly in the harbor, or into sewers which are to be modified or suppressed, shall execute in the interior of their houses, and according to the indications to be given them by the engineer in charge of the sewerage, all the necessary changes for uniting their conduits with the enclosure sewer or its affluents.

ART. 2. The connexion shall be made in the man-holes, which shall be constructed by the Government in the limits of the public street, at the points indicated by the proprietors themselves, who shall cause their conduits to empty in the man-holes, at the level assigned by the government, in establishing at their expense the grate prescribed by the order of May 17, 1847.*

I would here state that the proprietors without exception cheerfully complied with the execution of this order, and that some have had important works in bringing them down to the level of the sewer.

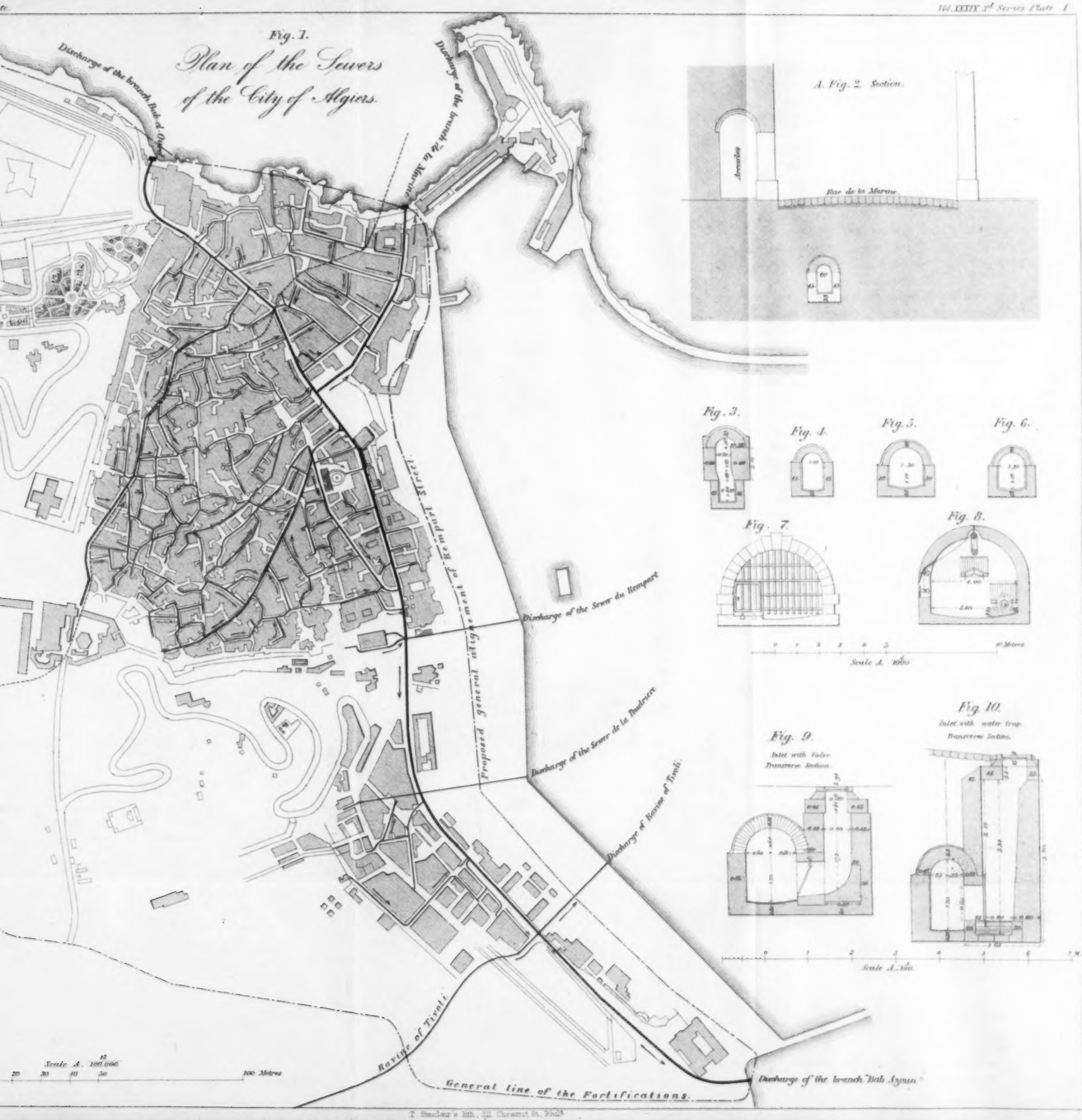
As for all the connexions made under the public street at the present time, two cases are presented, according as the depth of the invert of the private sewer is either above or below 5·25 ft.

In the first case, there is established under the arcades or pavements a man-hole into which empties the private sewer across the required grate. This grate is movable, and is retained in its place by a cross-piece with two screw rings inserted. The man-hole is closed by a cut-stone cover with an opening in it. The grate arrests the solids. If

* The decree of May, 1847, fixes the conditions on which the junction of the private conduits with the public sewers shall be made, and prescribes, among other matters, the placing of a grate with bars ·06 ft. interval. This grate is designed to prevent the introduction of solid matters into the public sewer.

Fig. 1.

Plan of the Sewers of the City of Algiers.


Discharge of the branch Bab el Oued
Discharge of the branch de la Marine
Proposed general alignement of the Rempart Street
Discharge of the Sewer du Rempart
Discharge of the Sewer de la Pudriere
Discharge of Ravine of Tivoli
Ravine of Tivoli
General line of the Fortifications.
Discharge of the branch Bab Azoun
Scale A. 1/100.000
20 30 40 50 100 Metres

A. Fig. 2. Section.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Scale A. 1/100

Fig. 9.

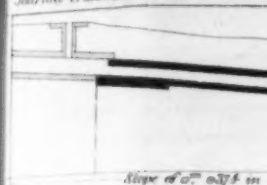
Inlet with Valve
Transverse Section.

Fig. 10.

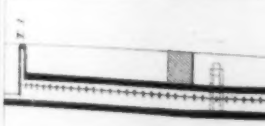
Inlet with water trap
Transverse Section.

Scale A. 1/50

T. Sinclair's Ith. 328 Chestnut St. Phila



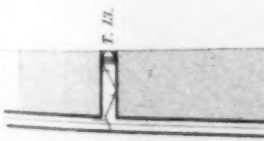
Slope of $0^{m}.376$ on



Slope per m. $0^{m}.03$ for a d. $25^{m}.09$ — Slope per

Slope per metre 0^{m} on

for a distance of $284^{m}.10$.



d $0^{m}.00187.162$ per metre for a distance

Fig. 1. *Profile of the Branch "Bab el Oued"*

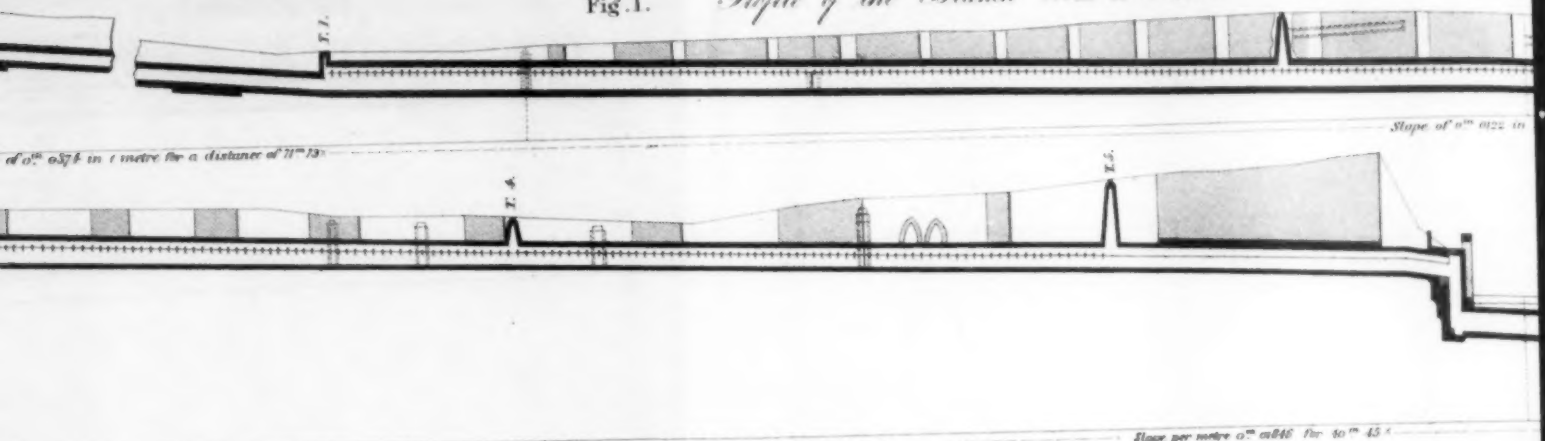


Fig. 2. *Profile of the Branch de la Marine*

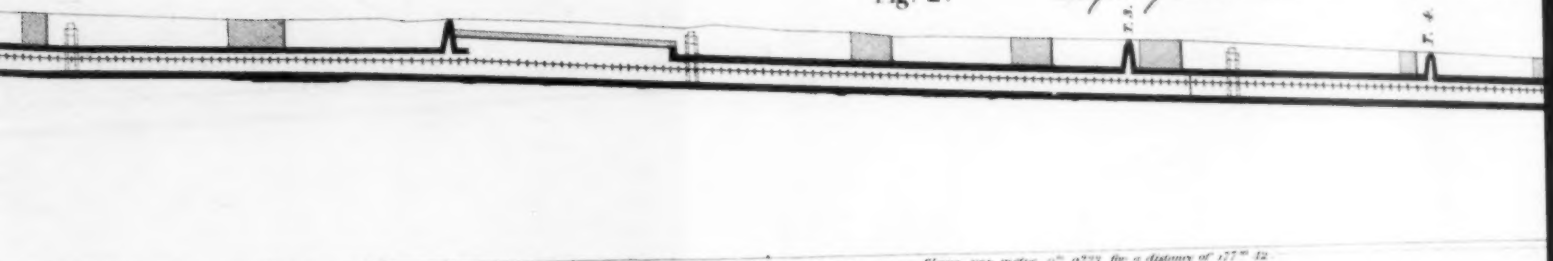
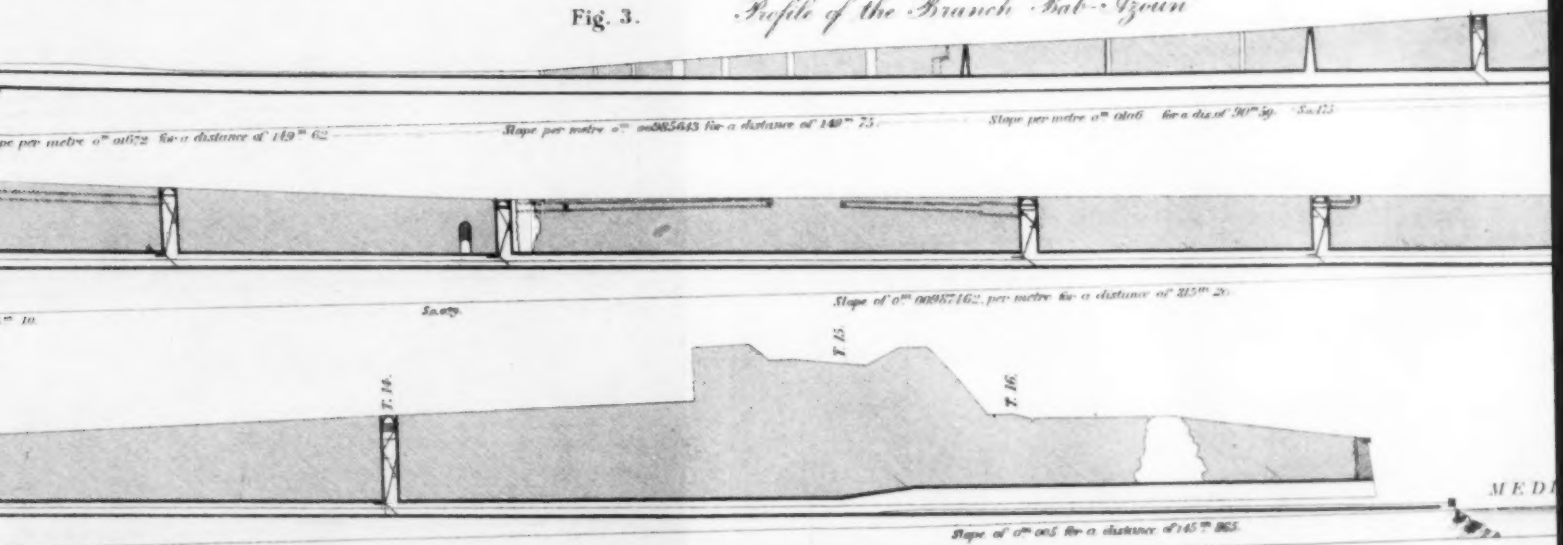


Fig. 3. *Profile of the Branch "Bab-Azoun"*



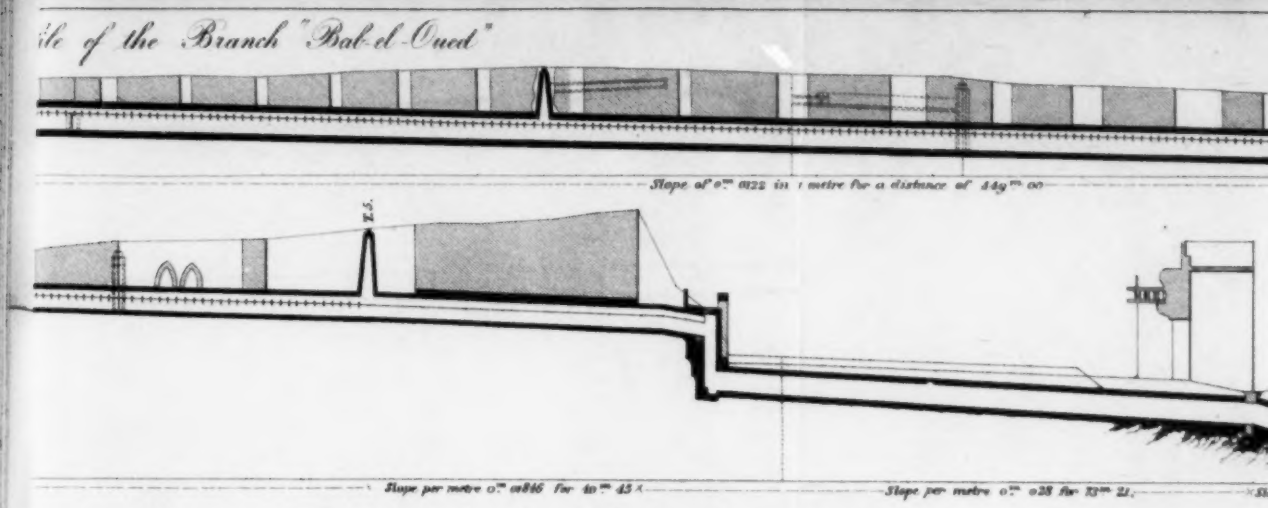
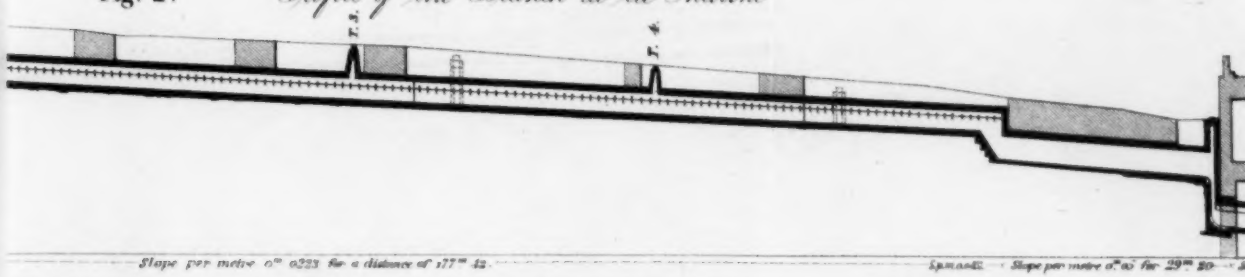
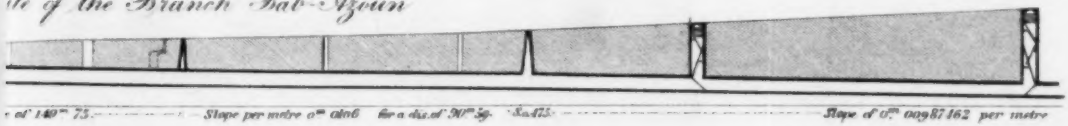
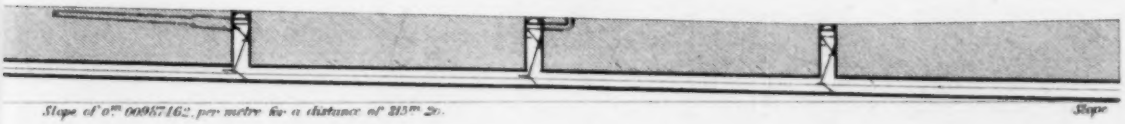


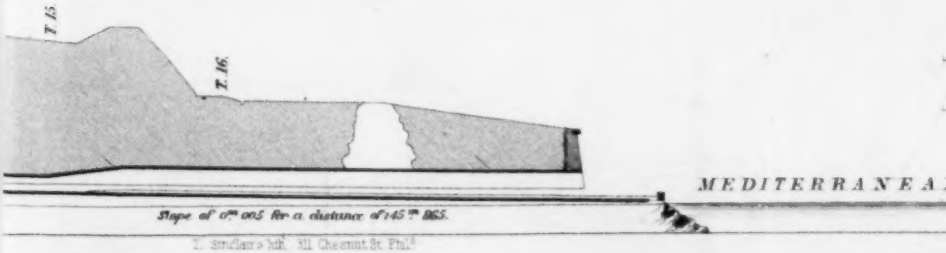
Fig. 2. *Profile of the Branch "de la Marine"*



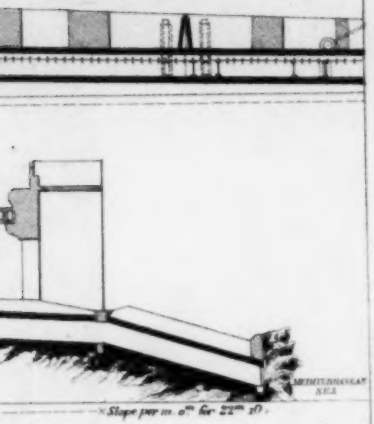
Profile of the Branch "Bab-Azoun"



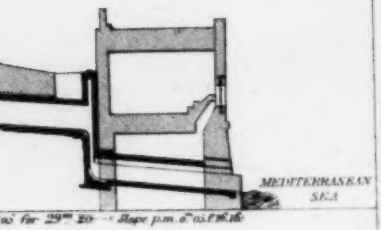




T. Sinclair's lith. 211 Chestnut St. Phil.a



Slope per m. 6m for 22m 20



90 for 29m 20 — Slope p.m. 6m 03.P.W.Bk

Scale 1/1000
40 80 120 metres

Scale 1/500
30 40 50 metres

the private conduit is choked up above the grate, it is cleansed with the greatest ease by opening the man-hole, and taking down the grate. The second case not admitting of cleansing in the man-hole, the latter is discarded, and the grate is placed in the enclosure sewer in the plane of the side walls.

We might undoubtedly have profited by the establishment under the arcades of a hydraulic chamber, and by this means have intercepted the gaseous currents, ascending from the main sewer to the house, and so put in practice the system generally followed in London for the private sewers. But it must be borne in mind that the houses of Algiers are not in the same condition with those of London. The latter enjoy the advantage of a distribution of water in every house, and can thus renew at will the reserve liquid of the hydraulic chamber; while our houses in Algiers are deprived of this means of cleansing, without which the hydraulic basin cannot well be maintained.

In the actual condition of the houses of Algiers, the hydraulic basin applied to private sewers, would be attended with inconveniences for the water inlet which I have already spoken of. The administration as yet have made no application of them in the man-holes under the arcades. As for individuals who are at perfect liberty to apply them in the interior of their houses, they do not find their local conditions to be such as to warrant the establishment of the system. In fact, the underground cellar found in all the houses of London, and which is so admirably adapted to the establishment and maintenance of hydraulic basins, does not exist in the houses of Algiers.

The private drain, in place of being found, as in London, immediately under the flagging of the cellar, sometimes crosses under the vestibule, sometimes under a store-house, sometimes under an underground piece, at a variable depth. We may conceive then, that these local dispositions are an obstacle in the establishment of hydraulic basins.

It may not be amiss to remark in passing, that the houses of London have a greater interest at stake in guarding against the exhalations of the public sewers, whose gas is driven back by the flood tide, than those of Algiers, which are naturally protected against this evil.

Simple Man-holes.—The simple man-holes established along the main sewer, are arranged so as to permit the introduction of cast iron tubes, ultimately to be placed upon the consols now awaiting them. They are all after the same model. Cut-stone bond is bedded in the arch of the sewer. The upper face is laid at a level of 1·18 ft. above the intrados of the key, and the lower face is cut conformably with the curve of the arch. The interior opening has the form of a vertical cylinder whose base formed of semicircles joined by a rectangle, has a length of 3·28 ft. in a parallel, and 1·96 ft. in a perpendicular direction to the sewer. This serves as the base of a conical chimney terminated above by a circular opening 1·96 ft. in diameter. The upper part of the man-hole is closed by a cut-stone frame supporting a tarred oak frame, under which re-

pose the cast iron frame and cover.* This disposition, as we have before observed, has also been applied to the water inlets. Openings made in the conical chimney allow the workmen to descend into the sewer. The-cut stone bond bedded in the arch is slightly rounded to facilitate the introduction of the cast iron pipes.

(To be Continued.)

Steam Engineering in 1859.† *The Mechanism of the Steam Engine.*

In all the machinery there are two distinctive classes of defects in construction. There are those which are so palpable as to bring discredit to the designer; and there are those, which, although in certain existence, may pass unnoticed and uncared for, during the life of a machine.

In the first class may be included, want of strength, bad materials, bad workmanship, and deficient knowledge in the expanding and contracting powers of materials; in the second class, we find chiefly, want of adaptation, complication, want of simplicity, errors of principle, and needless difficulties of access for examinations, repairs, and renewals.

We propose to say a few words on each of these classes of defects in steam machinery.

The engineering profession is indebted to the experiments of such eminent men as Fairbairn, Barlow, and others, for a practical knowledge of the strength of those materials used in the construction of a steam engine, and this knowledge is so easily accessible, that ignorance is inexcusable.

Constructive proficiency is obtainable in two ways: by experience, and by a careful study of the properties of materials. Many engineers depend almost wholly upon the former, few trust entirely to the latter; it is only when the two are combined, it deserves the title of engineering.

In old-established firms, where the same class of machine has been constructed for forty or fifty years, a degree of perfection is attained, difficult to be found in new establishments, although the manager may be most competent. There are exceptions to this general statement, and we might, perhaps, instance as one, the hydraulic machinery of Sir W. Armstrong, where there has been almost undisturbed success, and comparatively no failures with a new establishment, and a new class of machinery. We believe we can trace the cause of this success, but we do not feel at liberty to allude to the management in detail of any private establishment.

One strange anomaly in the manufacture of steam engines is the abominable specimens often found driving the tools of the firms who advertise to supply steam engines on the most improved principles. This is more the case in the North and Wales than in the South. You enter a large fitting shop, and hear in one corner, a wheezing, grinding

* This system was brought into use for the first time at Paris by M. Emmery, Engineer-in-Chief. (See his Memoir upon Sewers and Fountains.—*Annales des Ponts et Chaussees,* 1834, *Tome* x.)

† From the Lond. Artizan, Oct., 1859.

noise, which, upon examination, proves to be a "Pre-Adamite" steam engine, dirty, leaky, and most extravagant in fuel.

How is it that, with such an extended experience, amounting to nearly 100 years, we have yet, at the present time, frequent breakdowns and mishaps with our steam machinery? Surely, as such admirers of "precedents," we ought to be exempt from the mishaps of our Transatlantic friends, who do not hesitate to throw "precedent" overboard.

We believe the chief cause of our failures is the exclusive spirit existing among our manufacturing engineers, and although this exclusiveness tends to develop in competition, individual excellence and talent, it undoubtedly fosters positive ignorance and contempt for the improvement of others.

We could positively fill pages with particulars of constructive failures, not of small people, but of engineers, employing from 400 to 800 men, and we refer chiefly in these remarks, to marine engineers.

With land and locomotive engines, there are frequent opportunities for the manufacturer to observe defects in daily regular work, but in marine engines, it frequently happens the designer has had little or no experience at sea, and, unlike the Cornish man, he is too proud to "ax what he do'ant know." Hence it is, we find patentees abounding, who profess to supply us with engines so compact that they remind one mostly of those turned Chinese balls, one inside the other; but how they were put together, or how they can be separated, are questions difficult to solve.

It has been our misfortune, or, more correctly, *good* fortune, to be at sea in very bad weather, with new machinery, and we, therefore, can speak with certainty of the inconveniences—not to mention danger—of defective construction; too much or too little taper in cocks, soft brasses, slack nuts, inaccessible valves, accessible passages for dirt or coal, and imperfect joints, &c.

Beam engines for land or sea have had their day; they have been most efficient, and possess advantages not to be denied; but with the necessity for less weight, fewness of parts, and increased speed, they cannot compete with the oscillating, trunk, and other direct-acting engines.

For land purposes the horizontal engine, with long stroke and connecting rod, will multiply, on account of its small cost and simplicity.

For steam navigation, simplicity is a great desideratum, perhaps we might say as to mechanical construction, it is *the* great desideratum. Compactness is all very well, if it means not an unnecessary waste of room, but compared with efficiency or economy, it is not to be considered. A ton of coal saved, will give 40 cubic feet additional space for machinery, and it will be found that space is economized, not by extreme compactness, which generally induces neglect in maintenance, but by efficiency and economy of fuel; and it is highly satisfactory to know that, in adopting economical principles of construction, the economy attained is not confined to a mere saving of fuel, but of space, and we believe of capital also.

If it is possible to obtain 100 per cent. more power from one ton of coal, there is every reason to believe such increased power can be secured without a corresponding increase in the first cost of the machinery.

These remarks bring us to a subject we wish to impress upon our readers, namely, the dimensions of cylinder and speed of piston.

A large cylinder and a short stroke are synonymous with waste of fuel, and yet large cylinders and short strokes prevail; indeed, in many cases the stroke does not exceed half the diameter of the cylinder. That such engines can realize the benefits to be derived from expansive action is almost impossible, whilst the amount of surface exposed for premature condensation is nearly a maximum.

We are quite alive to the importance of direct-acting screw-engines, running at a high speed, to insure a minimum amount of slip, and the length of stroke is regulated by what is considered a safe speed of piston; and there is reason to fear all efforts to decrease the diameter, and increase the length of steam cylinders, must be very limited, as long as the steam pressure is only 20 or 25 lbs. per inch, and the air-pumps attached to the main engines. With higher pressure the diameter can be reduced, and with separate air-pump engines the number of revolutions and speed of piston can be safely increased.

To insure lightness in engine power, a maximum speed of piston is indispensable, and it may be taken for granted, that from 350 to 500 feet per minute, will be generally adopted for marine engines in a few years. If the speed of an engine is increased 50 per cent., the mean pressure remaining the same, an increase of 50 per cent. of power is thus obtained without any additional outlay of capital, except what is required to give the increased quantity of steam, and it is well known the cost of boilers is only about one-third of that of the engines to which they are attached.

Increased pressure, and increased speed of piston, we reiterate, are among the chief mainstays of future progress in steam power on land and sea.

As a natural consequence of an increased speed of piston, spur wheels, loose cranks, beams, levers, and all needless complications, must be dispensed with, steam must be applied direct to the resistance, and instead of *one* vast unwieldy machine, we must increase the number and decrease the size.

Mechanical lubrication is not sufficiently attended to in fast moving engines; by self-acting lubrication, heating is avoided, and oil saved, and yet, in our mercantile steam navy, how few screw engines are fitted with self-acting lubricators.

Land engines are hardly considered complete without governors for regulating their speed; whilst marine engines, with an ever varying load in a sea way, are only preserved from actual break-downs, by the constant attention of the engineer in charge—room again for improvement.

With reference to the *evils* of what is called a *compact* engine, we remember a case in which a pair of engines were put on board a ship,

so compact, that after running a short time, they were removed, simply because no engineer could be found, willing to risk his arms and fingers in keeping them in order; and, in a less degree, this is a state of things not at all uncommon at the present day.

There are various details worthy of attention and capable of great improvement, such as increased wearing surfaces, and the position of thrust-bearing, the latter too often forming a portion of engine framing, so as to throw crank pins, connecting rods, &c., out of truth, as the thrust-bearing wears.

And what shall we say about screw propellers? Who knows anything definite about them, except captains and masters of steam ships? They are the gentlemen to explain, with the greatest clearness, the precise action of the screw; the only misfortune is, that no two of these gentlemen agree.

We are inclined to the opinion that, if the present amount of experience in the diameter, pitch, and shape, of screw propellers was appreciated and applied, we could greatly increase their present duty.

One fact is proved beyond all doubt, that it is not advisable to have the pitch of a propeller more than 50 per cent. in excess of the diameter. The principles of construction included in what is called Griffiths' screw, are undoubtedly nearer the truth than any other; and there is a general tendency among engineers to adopt those principles, as far as they can, without actually infringing Mr. Griffiths' patents; but still the bulk of our marine engineers adhere to precedent too firmly, to profit by the general experience, and we have in existence a collection of propellers, only suitable for a museum of antiquities.

Supposing we have a good pair of engines, how do we place them in the ship? in a clean space by themselves—oh, no! *in the stoke-hole*. Yes, hundreds of screw engines, from 70 to 200 H. P., are working in the stoke-hole, placed there, we presume, to receive all the dust and dirt, to act as emery powder on the bearings, and to prevent the possibility of the engineers in charge, keeping the machinery clean—*another advantage* (?) of this arrangement, is the passage of cold air from the engine-skylight over and round the cylinders (in inverted engines) before it reaches the ash-pits and stoke-hole.

On land, generally, the engine is placed by itself, as it ought to be, but at sea, where repairs are more difficult and costly, grit and dirt are positively encouraged.

It rests with engineers themselves whether they are to have sufficient room on board ship, to place their engines so as to insure easy access for repairs, and perfect separation from the stoke-hole. Steamship owners oppose their own interests, by refusing proper space for machinery, and lose in economy and efficiency to an unknown extent.

We purposely avoid expressing any opinion on the several varieties of direct-acting engines now in use, each has its advantages and disadvantages, but there can be no doubt, a preference should be shown to a long stroke and a long connecting rod. Trunk engines are compact, but they expose a large surface for premature condensation. Oscillating engines are objectionable in many instances, on account of

the difficulty of obtaining a simple and effective expansion gear; but faults of detail in the mechanism, sink into comparative unimportance, in comparison with the faults we have alluded to in the "generation of steam" and its "application as a motive power."

Much latitude may be allowed in the position and disposition of cylinders, rods, levers, &c., but *no* latitude can be allowed in the application of correct principles of economy, in the construction of steam machinery; it is in this latter respect we are so very remiss, and whilst we have one hundred plans for some trifling and almost unimportant alteration of mechanism detail, we are sadly wanting in practical suggestions for solid improvement and permanent economy.

In concluding these very brief remarks on the mechanism of the steam engine, it is not consistent with the design of these papers to enlarge on mechanical details, nor to refer to questions quite separate from the economy of steam power, our chief aim being to draw attention to prominent defects, and especially those that increase, needlessly, the maintaining and working cost of steam power.

Who knows, with any certainty, the effective duty of different classes of steam engines, as compared with their indicated or total power? the power absorbed in friction may amount to 30, 40, 50, or 60 per cent., according to the perfection of the workmanship and arrangement of the parts of a steam engine, and yet how seldom is a dynamometer applied. On land, of late years, dynamometers have been much introduced, even for engines of only 10 to 20 H. P., but in marine engines, of 100 to 500 H.P., it might be supposed frictional knowledge and experience is of little importance, whether 100 or 200 H. P. is required to overcome friction, is not considered of sufficient importance to justify an outlay of £50 in a dynamometer.

In our next paper, we shall endeavor to give a resumé of all the chief points alluded to in this and the five preceding papers.

(To be Continued.)

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*Great Spans in Railway Bridges.**

The widest single span of any railway bridge in the world, is that of the Niagara Suspension-bridge, connecting the American and Canadian Railways, at Niagara Falls. The clear span is 822 feet. A still wider single span—one of 1224 feet—is being constructed for carrying the Lexington and Danville Railway at an elevation of 300 feet over the Kentucky river, in the United States. The next widest spans are those of the Britannia-bridge, 460 feet each. Then come the two great spans of the Saltash bridge, of 455 feet each. The next great railway span is that of the Conway bridge, of 400 feet. The next is the immense bridge carrying the Royal Eastern Prussian Railway over the Vistula, at Dirschau. This is an iron lattice bridge, having six spans of 397 feet 3 inches each. The Nogat Bridge, on the same line, has two iron lattice spans of 321 feet, and one span of 53 feet 6 inches. The great railway bridge recently opened at Cologne, has four lattice spans of 344 feet 6 inches each. The openings of the railway bridge of Kehl will be nearly as wide. The middle opening of

* From Herapath's Railway Journal, No. 1075.

the great Victoria-bridge at Montreal, is 330 feet wide, the other 24 openings being each 242 feet. The Chepstow bridge has a span of 306 feet, besides three spans of 100 feet each. The Boyne Viaduct has one lattice span of a clear width of 264 feet, and two side spans of 138 feet 8 inches each. The Newark Dyke-bridge, the largest example of Warren's trussed girders, has a span of 240 feet 6 inches. Several of the tubular bridges erected by E. Gouin & Co., of Paris, over the Garonne, the Lot, the Tarn, &c., have spans of 80 metres, or 262 feet. The Spey Viaduct, on the Inverness and Aberdeen Junction Railway, consists of a pair of box girders of a clear span of 230 feet. The tubular bridge at Brotherton has a span of 225 feet. The greatest timber span in a railway bridge, and now indeed the widest timber span in existence, is one of 275 feet, that of the Cascade bridge, on the New York and Erie Railway in the United States. The Market street (highway) bridge, formerly crossing the Schuylkill at Philadelphia, U. S., had a timber span of 340 feet; whilst a timber span of 390 feet, the widest ever attempted in that material, was constructed by John Grubenmann over the Limmat, in Germany, in 1794, and was burnt shortly afterwards by the French troops. Railway bridges with timber spans of 250 feet, are not uncommon in the United States. The great railway bridge across the Mississippi river, at Rock Island, has five timber spans of 250 feet each, besides three others of 150 feet. The bridge by which the Ohio and Mississippi Railway crosses the Great Miami river, has five timber spans of 250 feet each; and another railway bridge, having two timber spans of 260 feet each, crosses the Delaware river near Port Jervis, State of New York. The widest masonry span ever erected for railway purposes is one of 180 feet, carrying the Glasgow and South Western Railway over the river Ayr. The new railway bridge being carried across the Thames at Pimlico, will have four cast iron arches of 175 feet each, the widest cast iron spans, we believe, yet employed for railway purposes. The six spans of the celebrated High Level bridge at Newcastle, are but 125 feet each in width.—*The Engineer.*

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*A Building Coated with Water-glass.**

A friend who is in Paris has made for us a particular examination of the public buildings—the Palace of the Louvre and the Cathedral of Notre Dame—which have been coated with Prof. Kuhlmann's water-glass. The result, we grieve to say, is not very favorable. The theory is apparently right, yet the method of practically applying the silicate has yet to be sought by the French chemist. Rain, even in dry Paris, has been beforehand with the preparation. Before the silicate could absorb a sufficient quantity of carbonic acid, the moisture has got into it, and wholly destroyed its preservative powers. The experiment, we hear, is thus far pronounced a failure. Yet science is clearly on the track of discovery, and ere long it will probably conquer all the difficulties now standing in the way of a general use of the conservative powers of water-glass.

* From the Lond. Athenæum, Aug., 1859.

The following TABLE gives a comparison of the number of passengers, tons of goods and minerals, and heads of live stock carried in the years 1856, 1857, and 1858:

		Passengers.					General merchandise. Tons.	Minerals. Tons.	Number of Live Stock.			
		First class.	Second class.	Third class and parliamentary.	Holders of periodical tickets.	Total.			Cattle.	Sheep.	Pigs.	Total.
England,	1856	14,418,760	35,490,844	58,438,432	20,865	108,368,901	20,224,829	33,309,666	1,487,961	71,815 / 5,400,305 / 4,432	1,048,981	8,009,062
	1857	15,671,096	36,603,060	63,562,252	22,398	115,858,806	21,138,732	37,639,303	1,778,259	5,693,092 / 15,922	1,112,346	8,588,129
	1858	15,162,796	36,199,373	64,568,572	26,216	115,956,957	21,687,649	38,298,709	1,770,846	5,537,150	1,371,398	8,695,296
Scotland,	1856	1,664,005	1,952,240	9,476,226	4,767	13,097,238	2,683,184	7,527,843	300,600	980,748	48,923	1,330,271
	1857	1,823,542	2,180,284	10,723,694	5,983	14,733,503	2,909,139	8,527,893	331,443	1,042,568	37,973	1,411,984
	1858	1,983,821	2,150,334	10,647,854	6,959	14,788,968	2,895,916	9,040,903	316,458	1,062,638	47,496	1,426,592
Ireland,	1856	1,034,713	3,223,077	3,616,899	6,764	7,881,453	915,917	101,166	209,187	462,550	439,555	1,111,292
	1857	1,112,188	3,382,941	3,912,183	9,267	8,416,579	980,056	126,788	255,027	349,113	442,907	1,047,047
	1858	1,155,767	3,345,582	3,929,038	19,387	8,447,774	1,071,055	130,064	236,001	338,392	629,725	1,204,118
Great Britain and Ireland,	1856	17,117,477	40,666,162	71,531,557	32,396	129,347,592	23,823,930	40,938,675	1,997,748	71,815 / 6,843,603 / 4,432	1,537,459	10,450,625
	1857	18,606,826	42,166,285	78,198,129	37,648	139,008,888	25,027,927	46,293,984	2,364,729	7,084,773 / 15,922	1,593,226	11,047,160
	1858	18,302,384	41,693,289	79,145,464	52,562	139,193,699	25,654,620	47,469,676	2,323,305	6,938,160	2,048,619	11,326,006

And the following Table gives a comparison of the receipts for the same three years:—

		Passenger Receipts.					General merchandise.	Minerals.	Live Stock.	Total receipts from all sources of traffic.	Total working expenses calculated upon the average amount by those Companies who have supplied statements.	Proportion per cent. of working expenses to receipts.
		First class.	Second class.	Third class and parliamentary.	Miscellaneous, including luggage, parcels, carriages, horses, dogs, and mails.	Total.						
		£	£	£	£	£	£	£	£	£	£	
England,	1856	2,601,353	3,025,076	2,834,241	1,189,991	9,650,651	6,665,135	3,001,841	410,675	19,728,312	9,361,746	49
	1857	2,753,123	3,147,398	2,921,158	1,253,876	10,075,555	6,728,668	3,313,256	410,268	20,527,747	9,827,640	48
	1858	2,582,163	3,104,726	2,905,459	1,291,142	9,833,470	6,637,585	3,335,122	387,918	20,244,095	10,152,269	50
Scotland,	1856	232,130	171,588	436,564	121,525	961,807	739,426	570,677	47,307	2,319,217	1,090,031	47
	1857	251,184	178,778	471,452	127,282	1,028,676	767,297	657,502	47,913	2,501,478	1,100,650	44
	1858	250,203	174,885	472,598	134,114	1,031,800	765,403	692,893	46,837	2,536,933	1,116,250	44
Ireland,	1856	158,678	242,317	241,423	121,452	763,807	280,818	13,473	59,804	1,117,965	436,006	39
	1857	163,161	248,812	244,628	127,385	783,987	285,778	16,443	59,177	1,145,385	434,246	38
	1858	170,472	247,766	238,155	126,241	782,634	308,398	18,046	66,643	1,175,721	470,288	40
Great Britain and Ireland,	1856	2,992,161	3,438,981	3,512,228	1,432,968	11,376,338	7,685,379	3,585,991	517,786	23,165,494	10,887,783	47
	1857	3,167,468	3,574,988	3,637,218	1,508,544	11,888,218	7,781,743	3,987,201	517,358	24,174,610	11,362,536	47
	1858	3,002,838	3,527,377	3,616,192	1,551,497	11,697,904	7,711,386	4,046,061	501,398	23,956,749	11,738,807	49

The number of persons who suffered from accidents

The number of persons who suffered from accidents on railways in the years 1857 and 1858, compared with the number of persons who traveled, is exhibited in the following Table:—

DESCRIPTION OF PERSONS.	1857.								1858.							
	England.		Scotland.		Ireland.		Total on all railways in 1857.		England.		Scotland.		Ireland.		Total on all railways in 1858.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
Passengers killed or injured from causes beyond their own control,	24	606	1	25			25	631	25	386	1	23		10	26	419
Passengers killed or injured owing to their own misconduct or want of caution,	18	11	2	3	3	1	23	5	21	13	2	1	2	4	23	18
Total number of passengers killed or injured,	42	617	3	28	3	1	48	646	46	399	3	24	2	14	51	437
Servants of Company or of contractors killed or injured from causes beyond their own control,	14	28	1	9	3	2	18	39	10	47	6	1	1	4	17	52
Servants of Company or of contractors killed or injured owing to their own misconduct or want of caution,	59	28	7	3	9	3	75	34	71	31	30	11	13	7	114	49
Other persons crossing at level crossings,	23	5			2		25	5	17	4	1		3	1	21	5
Trespassers,	40	13	11	1	3		54	14	46	8	10	1	6	2	62	11
Suicide,	6						6		4		1				5	
Miscellaneous,	6		2		2		10		5			1	1	1	6	2
Total,	190	691	24	41	22	6	236	738	199	489	51	38	26	29	276	556
Total number of passengers conveyed,	115,858,806		14,733,503		8,416,579		139,008,888		115,956,957		14,788,968		8,447,774		139,193,699	

The following Table shows the proportion of passengers killed and injured from causes beyond their own control, per million, conveyed in the several years, from 1852 to 1858 inclusive:

	England.		Scotland.		Ireland.		Great Britain and Ireland.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
1852	·14	4·30	·00	5·80	0·00	3·20	·11	4·20
1853	·23	2·60	·09	4·50	2·40	1·60	·35	2·80
1854	·09	3·08	·16	3·51	0·14	0·57	·10	2·97
1855	·08	2·51	·08	4·50	0·14	0·97	·08	2·70
1856	·07	2·35	·00	1·92	0·00	0·25	·07	2·18
1857	·20	5·23	·06	1·69	0·00	0·00	·18	4·53
1858	·18	3·31	·07	1·55	0·00	1·18	·19	3·01

MECHANICS, PHYSICS, AND CHEMISTRY.

Aerometry. Translated from the Hydraulics of D'Aubuisson de Voisins. By J. BENNETT.

(Continued from page 192.)

CHAPTER SECOND.—*Blowing Machines.*

The name of *blowing machines* is given to the great bellows employed in the arts to produce a continuous blast, either for animating the fires of forges and other metallurgic works, or as ventilators.

Formerly these machines were but bellows of the common form, lined with leather, or rather double wooden boxes; the one was fixed, the other was movable; the lining consisted also of wooden strips.

Now, they are formed of great cylindrical or prismatic pump bodies of cast iron, or of wood, or marble, in which moves a piston lined with leather or wooden strips; it has two valves, the one for the inlet, the other for the outlet of the air; they are single or double acting.*

In some places they use *hydraulic blowers* where the water plays the part of the piston, but of an immovable piston, and the pump barrel alone moves; sometimes it consists of a great vessel, a kind of gasometer, ascending and descending in a basin filled with water; sometimes of casks half filled with water furnished with suitable partitions and valves, which turn upon their axes.†

In mountainous countries, having great water-falls, they make frequent use of "*trombes*;" these are shafts, or vertical and hollow cylinders slightly contracted just below the upper end, in which falls a current of water carrying with it the air which continually enters through the small openings or *exhausters* pierced below the contraction. This air enters the box in which the shafts abut, and depart through a tube placed for that purpose.

Mention was made, in No. 471, of the Archimedes Screw being used as a blowing machine. I am not familiar with them. It is said that one is used successfully at a blast furnace for smelting iron, at the works of M. Koechlin, near Mulhouse.

These different machines deliver a current of air at a given point through the intervention of *wind-trunks* or long conduits. Sometimes the pipes are fitted immediately to them; but more frequently, and when it is proposed to maintain a continuous blast, two, three, or four, pump barrels discharge their air into a common reservoir whence depart the conduits which lead it to its destination.

Effect of Blowing Machines.—The dynamic force imparted to this air, that it may enter, pass through, and issue, from the pipes with a given quantity and velocity, will represent the effect of the machine considered only as a blower, all other resistances being disregarded. The useful effect will consist solely of the action required to drive

* A description of these machines may be found in the *Richesse* Minérale of M. Heron de Villefosse, Tome iii; and in metallurgic treatises, especially in the *Manuel de la Metallurgie du fer*, by M. Karsten, Tome ii of the French translation of 1830.

† See description of one of these machines which I published in Tome ix of *Annales des Mines*, 1821.

through the orifice at the end of the pipe, this quantity of air with this velocity.

533. *Useful Effect.*—The useful effect of a machine is generally estimated by the weight of the body moved, multiplied by the height due to the velocity of the motion. Moreover, when any fluid issues from a vessel under a certain pressure, the velocity of efflux has, for the height due, the height of a column of the issuing fluid whose weight equals the pressure (14). According to these two principles, *the useful effect of a blowing machine will be expressed by the weight of the air emitted in* 1 *sec., and by the height due the velocity of emission.*

I give a direct demonstration of this fundamental theorem. Let us take for the machine, a cylinder with a piston, to which is fitted an efflux ajutage. Designate by Σ the surface of the piston, by v its ascensional velocity, by h the height of the mercury manometer placed upon the upper base of the cylinder, by Δ the specific weight of the mercury, by σ the section of the outlet orifice, corrected for the effect of contraction, by Υ the velocity of the air's efflux, by δ the specific weight of this fluid, and, lastly, by ρ the absolute weight of that issuing in one second. We have, manifestly, $\rho = \sigma \Upsilon \delta$. Since the flowage is permanent during the raising of the piston, (excepting the first instant,) the velocities will be in the inverse ratio of the sections, and we shall have $\Sigma v = \sigma \Upsilon$

$$\text{and consequently } \rho = \Sigma v \delta, \text{ or } v = \frac{\rho}{\Sigma \delta}$$

Moreover, the effort made by the piston to compress the air above it so as to give it the elastic force h, in virtue of which, it issues with the velocity Υ; this effort, I say, is evidently equal to that required for raising a layer of mercury spread upon the piston, whose thickness is h; now, this effort is manifestly represented by the weight of this layer, which is $\Sigma h \Delta$. The effect of a machine consisting of the weight raised, multiplied by the height of the elevation in 1 sec., a height which here is v, that of the blowing

$$\text{cylinder will be} \qquad \Sigma h \Delta v = \Sigma h \Delta \frac{\rho}{\Sigma \delta} = \rho h \frac{\Delta}{\delta}$$

an expression in which the first factor is the weight of the air emitted, and the second is the weight due the velocity of emission. (500.)

This height is also equal to $\frac{\Upsilon^2}{2g}$; the mass m of air whose weight is ρ, being $\frac{\rho}{g}$, we shall also have, for the expression of the effect, $\frac{1}{2} m \Upsilon^2$; that is to say, the effect of a blowing machine, is one-half of the vis viva of the issuing air.

534. When the ajutage is immediately attached to the machine, the weight of the air issuing in 1 sec., is (510)

$$30{\cdot}787 \sqrt{\frac{b + h}{t}}\, d^2 \sqrt{h}$$

and the height due to the velocity of issue, equals (500)

$$26103{\cdot}8 \, \frac{t}{b + h} h;$$

thus the useful effect will be

$$803660 \sqrt{\frac{t}{b + h}}\, d^2 h \sqrt{h}.$$

535. If the air, instead of issuing immediately from the reservoir through an ajutage fitted to it, should have to pass through a long

pipe, at the end of which is fitted the outlet orifice; where the manometer has the height h, the useful effect will be

$$803660\sqrt{\frac{\text{T}}{b+h}}\, d^2\, h\, \sqrt{h}$$

As in applications of these formulæ to practice, we can only arrive at approximations, we may substitute for T and $b+h$ the mean values already indicated (511) and we shall have the useful effect of a blowing machine; h being the height of the manometer placed at the end of the conduit.

536. *Total Effect.*—Whatever may be the conduit, so long as h preserves the same value, the weight of air issuing in 1 sec. still remains $48{\cdot}073\, d^2\sqrt{h}$ (511), and the effort exerted at the end of the conduit to drive out the air is always represented by h; but, at the entrance of the pipe, where the machine acts, there is exerted an effort, H, which is h increased by the resistance H—h, experienced by the air in the tubes; so that the quantity of action impressed, or the dynamic effect, is the above expression increased in the ratio of H to h, and, consequently, $514300\, d^2\, \text{H}\, \sqrt{h}$.

537. It is seldom that the heights H and h are found, as quantities given or sought, in questions offered for solution, and it is proper that they should be eliminated from the expression of the effect. We, therefore, take for H its value deduced from the relation given in No. 523, and we have for the effect,

$$514300\, d^2\, h^{\frac{3}{2}} \left(1 + 0{\cdot}0238\, \frac{\text{L}\, d^4}{\text{D}^5}\right).$$

Then we put for $h^{\frac{3}{2}}$ its value derived from the equation

$$\rho = 48{\cdot}073\, d^2\, \sqrt{h} \quad (511),$$

where ρ is the weight of the air discharged in 1 sec., and we have, all reductions being made,

$$0{\cdot}11017\, \rho^3 \left(\frac{\text{L}}{\text{D}^5} + \frac{42}{d^4}\right).$$

Most frequently the quantity of air issuing from a blowing machine is expressed in volume and not in weight. Substituting, then, Q for ρ, and remembering that, under the pressure 2·493 ft. and at the temperature 53·6°; $\rho = 0{\cdot}0325\, \frac{2{\cdot}4934}{1{\cdot}048}\, \text{Q}$, we shall have

$$\cdot 0000509\, \text{Q}^3 \left(\frac{\text{L}}{\text{D}^5} + \frac{42}{d^4}\right) \text{lbs. ft.}$$

538. Such is the force to be imparted to the air to drive it in the conduit; but that to be impressed upon the machine, upon the piston which drives the air, for example, is considerably more, for it has to overcome the friction of the piston against the sides of the cylinder, &c. Moreover, as in pumps, (431), there is a *prejudicial space* seated be-

tween the piston at the highest point of its stroke and the upper base of the cylinder, the air which fills this space alternately contracts and dilates at each oscillation of the piston, and without escaping; whence we have a new employment for the motive action. Still further a notable portion of the air inhaled, a quarter, a third, and frequently more, escapes through the lining of the piston, or through the imperfect joints; though this may be without a useful effect, there is, nevertheless, required a force to drive it up to the points of escape; so that the total force to be imparted, or the effect E, will exceed the above expression; we therefore give it a suitable increase in multiplying by n, and we have $E = \cdot 0000509\, n\, Q^3 \left(\frac{L}{D^5} + \frac{42}{d^4}\right)$.

539. *Fundamental Equations.*—Here, as for all machines, (289,) we have $E = n\,p\,h$, p and h being the weight and the fall of the motive water. Making $\frac{n^1}{n} = m$, the equation for resolving the different questions relating to blowing machines will be

$$m\,p\,h = \cdot 0000509\, Q^3 \left(\frac{L}{D^5} + \frac{42}{d^4}\right).$$

The co-efficient m referred to the useful effect, will vary with the machine used, and will have values which we proceed to indicate.

540. In blowing machines, as in hydraulic wheels, m, or the ratio between the effect produced and the motor-force employed to produce it, varies with the different kinds of machines, and for each kind we may adopt a mean value. Thus,

For a good machine with pistons, composed of cast iron cylinders truly bored and worked by a steam engine, we admit $m = 0{\cdot}50$.

For a common machine with pistons, moved by a well constructed bucket wheel, including the inevitable losses of air, we shall have, according to my observations upon this kind of blowers,* 0·24.

If the motor water acts upon a wheel by a shock and not by the weight, it would not be over 0·14.

In hydraulic blowers, where the friction against the water is small and where there are but few losses of air, according as the wheel is struck above or below, we have $m = 0{\cdot}30$ or 0·18.

Finally, for some well arranged "*trombes*," according to the observations of MM. Tardy and Thibaud as well as with those made by M. Marrot and myself in concert, $m = 0{\cdot}10$.

For machines of the same kind, the co-efficients to be assigned vary up to a fifth and even a fourth more or less, according as they approach a greater or less perfection as respects construction and disposition and a good or bad maintenance.

541. *Expression of Discharge.*—That we may determine the dis-

* *Observations sur les machines soufflantes a pistons des usines a fer du sud-ouest de la France*; dans les Annales des Mines, Tome xi, 1825.

charge of a given conduit, we must free Q from the above equation, (539), and we shall have

$$Q = 26{\cdot}966 \sqrt[3]{\frac{m\,p\,h}{\frac{L}{D^5} + \frac{42}{d^4}}}.$$

If the conduit is entirely open, by increasing the co-efficient in the ratio of 4030 to 4321, (525), we shall have

$$Q = 28{\cdot}31 \sqrt[3]{\frac{m\,p\,h\,D^5}{L + 42\,D}}.$$

542. *Expression of Diameter.*—We have frequently to determine the diameter to be given to a conduit; the fundamental equation gives for this determination,

$$D = 0{\cdot}13849 \sqrt[5]{\frac{L\,Q^3}{m\,p\,h - 0{\cdot}00213\frac{Q^3}{d^4}}}.$$

The velocity of efflux is sometimes a part of the problem to be resolved. We introduce it in the formulæ by substituting for d its value as a function of V as given by the relation $Q = 0{\cdot}93\,\pi^1\,d^2\,V$; and from this substitution we have

$$D = {\cdot}13849 \sqrt[5]{\frac{L\,Q^3}{m\,p\,h - {\cdot}001136\,Q\,V^2}}.$$

543. *Conduits with Heated Air.*—In what we have thus far said, the conduits were supposed to have conveyed an air of uniform temperature. But, for several years we have found it advantageous to blow the fires of certain metallurgic works with air heated at least to 572° of thermometric temperature; consequently their conduits must pass through furnaces, which give them this high temperature. If t' is the number of degrees, let us make $1 + 0{\cdot}00208\,(t' - 32°) = T'$; and let h always be the height of the manometer of mercury placed upon the conduit immediately before the outlet ajutage we shall then have

$$Q = 948{\cdot}18\,d^2\sqrt{h\frac{T'}{b + h}},$$

or, the air being taken at the temperature and pressure of the atmosphere,

$$Q = 948{\cdot}18\,d^2\frac{T}{b}\sqrt{h\frac{b + h}{T'}};$$

and for the useful effect e, it will be

$$e = 803660\,d^2\,h\sqrt{h\frac{T'}{b + h}}.$$

As for the dynamic effect or force to be imparted to the air on its

entering the conduit, if H is always the manometric effort at the inlet, we may still admit $803660\, d^2\, h \sqrt{h \frac{T'}{b+h}}$.

But, in view of the elevation of the temperature between the points where H and h is taken, the law which unites these two quantities will no longer be that given by the experiments made at the mines of Rancié, and we cannot arrive at an expression of the force imparted similar to that of No. 537.

Still, in short conduits of a great diameter compared to that of the outlet orifice, and where, consequently, H differs but little from h, the above expression of useful effect may, with a slight increase, be taken for that of the force to be imparted. This force will be to that which would be required if the air had not been heated, h remaining the same, as $\sqrt{T}$ is to $\sqrt{T}$. Thus, for hot air at 662°, that of the atmosphere being 53·6°, the force would have been more considerable in the ratio of 149 to 100; and notwithstanding this, the quantity of air blown would have been less in the ratio of 67 to 100: it would have required more than double the force to have obtained the same quantity. Finally, by taking from the equation of discharge the value of h, and substituting it in the expression of the effect, we shall have the exact ratio between the two forces.

M. Combes, in a Memoir which we shall soon refer to, has deduced from his own peculiar theory, the following expression for the force to be imparted to air:

$$\frac{\cdot 22652\, \Delta\, Q^3 q}{g\, \pi^2}\left(\frac{1}{m^2 d^4} + \frac{0{\cdot}0238}{D^5}\left(\frac{L'}{\Delta} + L''\right) + \frac{2 \log.\text{hyp.}\, \Delta}{D^4}\right),$$

in which Δ is the ratio of T' to T, q the weight of a cubic foot of atmospheric air, L' the length of the portion of the conduit from the origin up to the heating furnace, L'' the other portion.

For the ratio of this force to that which would have been required for air not heated, Q remaining the same, M. Combes finds a value a little below

$$\Delta\left(1 + \frac{2\, \text{hyp. log.}\, \Delta}{\frac{D^4}{m^2 d^4} + 0{\cdot}0238 \frac{L}{D}}\right).$$

544. *Examples.*—I. There is required, for a blast-furnace to smelt iron by means of coke, 35·316 cubic feet of air per second, arriving at the furnace with a velocity of 492·12 feet. It is driven by a steam engine, and the wind-trunk is to have a length of 311·67 feet, and a diameter of ·984 feet. What force must such a machine have?

The question is reduced to the determination of $p\, h$. The fundamental equation will give its immediate value, when the condition relative to the velocity is expressed therein, or, in other words, when the value of d fulfilling this condition is introduced in it; this value will be $\cdot 31344 \left(= \sqrt{\frac{35{\cdot}316}{0{\cdot}93\, \pi' 492{\cdot}12}}\right)$. (The air may be let upon the furnace through two nozzles of 0·223 ft., or through three of 0·177 ft. diameter.)

The blasting being put in operation by a steam engine, we shall have as a mean, $m = 0{\cdot}50$. Moreover, $Q = 35{\cdot}316$ cub. ft., $L = 311{\cdot}67$ ft., $D = 0{\cdot}984$ ft., and $d = {\cdot}31344$ ft.

$$\text{Thus, } p\, h = \frac{\cdot 0000509}{0{\cdot}5} \times 35{\cdot}316^3 \left(\frac{311{\cdot}67}{{\cdot}984^5} + \frac{42}{({\cdot}31344)^4}\right) = 21047:$$

that is to say, there will be required a machine with a force of 21047 lbs. ft.

or of $39 \left(= \frac{21047}{542{\cdot}69}\right)$ steam horse powers.

If, all else being equal in the data of the problem, the diameter of the conduit, instead of being 0·984 ft., had been but 0·82, it would have required a force of 43.

"	0·65,	"	"	57.
"	0·49,	"	"	120.
"	0·41,	"	"	254.
"	0·328,	"	"	714.
"	0·31344,	(equal diameter of nozzle)		889.

This shows *the advantage of giving to conduits a great diameter as compared with that of the orifices of the nozzles at their extremities*, as in the actual example.

But, experiments upon the ventilator of the mines of Rancié, furnish a striking and direct proof of this advantage. For example, in the experiments whose results are noted below, and which were made at the end of a conduit 1269 ft. long, and ·328 ft. diameter, if we represent by 1 the motive power at the origin of the conduit, the useful power remaining at the extremity, will be expressed by the numbers of the last column; and we see that they diminish, very rapidly, with the diminution of D, the diameter of the conduit, *d*, that of the orifice remaining the same.

D	H	*h*	$\frac{h}{H}$
	Feet.	Feet.	
5 *d*	·1774	·1555	0·88
$3\frac{1}{2}$ *d*	·1774	·1007	0·57
$2\frac{1}{2}$ *d*	·1509	·0531	0·35
2 *d*	·1328	·0177	0·13

II. If, in the blowers of the given example, the pistons instead of being worked by a steam engine, were driven by a bucket-wheel under a fall of 16·4 ft., all the other data of the problem remaining the same, we should have made $m = 0{\cdot}24$, and should have $p\,h = 43871$ lbs. ft.; and since $h = 16{\cdot}4$, $p = 2675$ lbs.; that is to say, to produce the effect required, there would be needed a current yielding 2675 lbs., or 42·839 cub. ft. of water per second.

III. A ventilator is to be built to convey 2·825 cub. ft. of air per second 4921 ft from the machine which supplies it. This machine is a "trombe," to which we give 1·765 cub. ft., or 110·27 lbs. of water with a fall of 18·04 ft.; what should be the diameter of the conduit?

We have Q = 2·825 cub. ft., L = 4921 ft., $p = 110{\cdot}27$ lbs., $h = 18{\cdot}04$ ft., and (540) $m = 0{\cdot}10$.

As the conduit should be entirely open at the end, we must use the second of the two equations of No. 541; it will give $D^5 = \frac{Q^3 (L + 42\,D)}{(28{\cdot}31)^3\, m\, p\, h}$. Neglecting at first the term 42 D, we shall have, with the above numerical values, $D^5 = {\cdot}0245$, and extracting the fifth root, $D = {\cdot}4765$. Consequently, $42\,D = 20{\cdot}01$: putting this term in the formula, we shall obtain $D = {\cdot}4769$.

To provide for all miscalculation, in the execution we raise the diameter to 0·492 ft., and even more, if the size of the sheet iron plates, of which the conduit is composed, will admit of greater dimensions without a material increase of cost.

NOTE.—In 1823, I was called to establish, as I have said before (522), air conduits for the mines of Rancié. I sought among the authors who have discussed the motion of fluids for fit rules to direct me in this work, and found none. Appreciating their utility, I attempted their determination. For this purpose, I carefully observed the numerous manometric phenomena presented at the successive laying of the parts of the different conduits; and to a certain extent they dictated to me the formulæ placed in this section. They are the immediate results of experiment, they are simple, and they will amply suffice those engineers who may be engaged on similar works.

Since then, two distinguished geometricians, MM. Navier and Poncelet, taking as a basis some hypotheses, and profiting by the results of my observations, have given a mathematical and general theory of the motion of aeriform fluids. That of M. Navier may be seen in his *Mèmoire sur l'écoulement des fluides élastiques dans les vases*

et les tuyaux de conduite. (*Mémoire de l'Académie des Sciences de l'Institut.* 1829.) The equation of motion established by this Savant, is

$$\text{H} - h = \left(1 + \left(\frac{1}{m'} - 1\right)^2 + 0{\cdot}0216\,\frac{\text{L}}{\text{D}}\right)\frac{h\,m^2\,d^4}{\text{D}^4\left(1 - \frac{m^2\,d^4}{\text{D}^4}\right)}.$$

It differs from that which I have given in No. 523:

1st. By the term $1 + \left(\frac{1}{m'} - 1\right)^2$, whose value is only 1·006, and refers to the contraction experienced by the air at its entrance in the conduit. I have remarked (520) that the effect of this contraction was comprised in my co-efficient 0·0238.

2d. By the term $1 - \frac{m^2\,d^4}{\text{D}^4}$, which I have admitted in theory in a somewhat different form (521), but experiment induced me to suppress it. For most of the cases presented in practice, it may be neglected, and the formula of M. Poncelet will not differ sensibly from mine in its results.

Still later, in 1837, M. Combes has discussed the theoretic question of the motion of air in conduits, by a method differing in some respects from that of M. Navier. In his formula, he preserves a term relative to the weight of the air in the conduit: a term which M. Poncelet has discarded from his, since it had but a trifling influence, and which I have designedly omitted in mine, because my conduits were a little inclined; but it may have a marked effect in some circumstances, for example, in the ventilation of mine shafts, or for high chimneys of certain works. Designating by H' the difference of level between the two ends of the conduit (quantity relative to this term), by Ω the section of the conduit, by χ its perimeter, by a the section of the outlet orifice, by μ' the co-efficient of contraction relating to it, by μ that belonging to the cylindrical tubes, by p_0 the pressure at the entrance of the conduit, by p_1 the pressure upon the orifice of the outlet, by q_1 the weight of a cubic foot of air under the last pressure, which is that of the atmosphere, by ζ a co-efficient to be deduced from the experiment (mine gave $8\,\zeta = 0{\cdot}0238$), finally, by Q the volume of air delivered, taken at the pressure and temperature of the atmosphere, M. Combes arrives at the equation,

$$\text{Q} = \sqrt{\frac{2\,g\left(\frac{p_0 - p_1}{q_1} \mp \text{H}'\right)}{\frac{1}{\mu'^2\,a^2} - \frac{1}{\mu'^2\,\Omega^2} + \frac{1}{m^2\,\Omega^2} + \frac{2}{\Omega^2}\,\zeta\,\frac{\chi}{\Omega}\,\text{L}}}.$$

For cylindrical conduits, observing that μ' does not differ sensibly from μ, and that $\frac{p_0 - p_1}{q_1} = \phi\,(b + \text{H}) - \phi\,b = \phi\,\text{H}$; ϕ being the ratio of the specific weight of mercury to that of atmospheric air ($\phi = 10969$ at 2·493 ft. pressure, and 53·6° temperature), this equation reduces to

$$\text{Q} = 4278\sqrt{\frac{(\text{H} \mp 0{\cdot}0000915\,\text{H}')\,\text{D}^5}{\text{L} + 48{\cdot}6\,\frac{\text{D}^5}{d^4}}}.$$

That which I have established is, (524)

$$\text{Q} = 4030\sqrt{\frac{\text{H}\,\text{D}^5}{\text{L} + 42\,\frac{\text{D}^5}{d^4}}}.$$

(To be Continued.)

For the Journal of the Franklin Institute.

Fall of the Pemberton Mill.

We have collected from authentic sources, the following particulars relating to this ill-fated structure.

The Pemberton Mill, an extensive establishment at Lawrence in Massachusetts, was erected in 1853 by a Boston Company for the purpose of manufacturing colored cotton goods. The Essex Company, the projectors of Lawrence, and the original owners of all the mill sites and most of the available building lots in the new city, on learning the intentions of the Company to erect a large mill in some locality not very distant from Boston, were desirous of having it at Lawrence in order to get the benefit in the sale of their building lots, resulting from the considerable influx of population that would necessarily take place in connexion with such an enterprise. As an inducement, they offered to furnish the mill site and six mill powers, gratis; subject only, to the usual rent of three hundred dollars per mill power per annum, reserved on the mill powers disposed of by them. These terms were accepted, on the Essex Company's undertaking to erect such buildings, &c., as the new Company might require, at cost, on a credit of five years.

Under this contract, the building known as the Pemberton Mill was built by the Essex Company under the superintendence of their engineer, Capt. Charles H. Bigelow, formerly of the U. S. Engineer Corps. The requirements of the new establishment were specified from time to time by its proprietors represented by Mr. J. P. Putnam; and the duty of the engineer of the Essex Company appears to have been limited to the proper construction of the works. The duties and responsibilities of the different persons acting together do not, however, appear to have been defined with much precision; all seem to have been anxious to promote the enterprise, and all undoubtedly acted in good faith; but among them, they committed the errors which have been followed by such awful consequences.

The principal building, which alone fell, was of brick, two hundred and eighty-four feet long, eighty-four feet wide outside, and five stories high, with a roof nearly flat. At the northerly end was a wing, which did not fall until after the fire, sixty feet long and thirty-seven feet wide, and of the same height as the mill, in which were the counting room, cloth room, and various other offices. There were also several detached buildings, viz: the dye house, under which there were three turbine water wheels, of about two hundred horse power each, furnishing the required power for the whole establishment; the picking house, cotton house, boarding-houses, &c.

The machinery comprised about 27,000 spindles, with all the other machinery requisite for making, from the raw cotton to the finished goods, a variety of fabrics composed of white and colored yarns. The entire cost of the establishment was about eight hundred and forty thousand dollars. It was carried on about three years by the original pro-

prietors until in 1857, during the panic, they deemed it expedient to suspend manufacturing operations. Subsequently the property was sold by auction, for three hundred and twenty-five thousand dollars, to Messrs. Nevins and Howe, the proprietors at the time of the fall.

The new proprietors made no material change in any part of the establishment, and were understood to be doing a very profitable business up to the time of the catastrophe.

Within the last ten or fifteen years, a change has taken place in the character of the buildings erected in the Eastern States for the cotton manufacture. It has been found that a more advantageous arrangement of the machinery, can be made in mills of greater width than had previously been erected. Wider rooms, to be properly lighted, required larger windows, which again required higher stories and wider bays. In the conception of the Pemberton Mill, these new ideas had been pushed to an extreme; and evidently required great caution and study in those charged with its construction.

The stability of the building seems never to have been questioned, or even discussed. By the new proprietors, its unusual freedom from vibration seems to have been the only point particularly discussed, and this could have been only a subject of congratulation. All went on prosperously until Tuesday, January 10th, 1860, at a few minutes before five o'clock in the afternoon, when, without the least warning, the entire building fell to the ground; probably not more than one minute elapsing from the first crack, until the crash was over.* About six hundred and seventy persons were in the building at the time, nearly all of whom were buried in the ruins.

Three weeks after the accident, the following statement was made of the number of sufferers:

Killed outright 83, since dead 3, total dead, . . .	86
Badly injured, ...	116
Injured, but not seriously, ...	159
Total killed and wounded,	361

The floors fell within the lines of the walls, and nearly vertically; the walls fell outwards. The machines in a cotton mill, as every one knows, are arranged in regular rows, with alleys between, generally of three feet or more in width, in which the duties of the operatives are performed. The machines in all cotton mills, as a rule, are fastened down to the floors. The floors were of four thicknesses of plank and boards, crossing each other in different directions and strongly nailed together; and when they fell, although much rent and broken, it was in large areas, on which the machines, generally, retained their places, and the frames of the machines having great strength, and a certain degree of uniformity, as to height, in each room, as the floors fell one on the other, they were prevented from coming in contact by the machines; so that after the fall, the general character of the ruins of the interior of the building, was this; the floors lay nearly horizontally, one above the other, say two to four feet apart, the spaces between them being occupied by the machines in nearly the same relative posi-

* The fall commenced near the southerly end, and extended northerly about as fast as a person could run.

tions that they occupied before the fall. The operatives must nearly all have been in the alleys, and after the fall, found themselves in spaces of the width of the alleys, and of a height nearly that of the machines. With this explanation, it is less difficult to understand how it happened that so small a proportion were killed.

At the time of the fall, the gas burners were nearly all lighted, and, at first view, it appears one of the most extraordinary circumstances connected with the catastrophe, that the ruins were not in flames the moment after the building fell. There could not have been less than one hundred tons of cotton, in various stages of manufacture, in the mill at the time. Mr. Chase, the superintendent of the mill, in his evidence before the Coroner's Jury, estimates the stock at sixty-five tons, not including the lower story occupied by the looms. Every machine had more or less cotton about it, and generally in a form highly favorable to rapid ignition. The gas was, undoubtedly, extinguished before a single burner, out of the hundreds that were lighted, came in contact with any cotton. This may have happened from the main gas pipe being among the first things broken,* or what is more probable, from the collapse of the floors, causing a pressure of air throughout the whole building, greater than the pressure of gas in the pipes; this latter is usually equal to about two inches of water above the pressure of the atmosphere, say $\frac{1}{200}$ of an atmosphere. It is easy to see that before the burners, which were attached to the ceilings, could have reached the cotton, which was, probably in all cases, two feet or more below them, the action of the falling floors, like the boards of the blacksmith's bellows, may have caused a pressure of air far exceeding this, and a very small excess of pressure would have driven the air into the pipes, through the burners, and, of course, extinguished the lights.

About four hours after the fall, the cotton in the ruins was accidentally set on fire by the breaking of a lantern in the hands of some person, among the great number at work, extricating the dead, wounded, and imprisoned. The fire was kept in check for some time by the application of immense quantities of water from hydrants, force pumps of the neighboring mills, and hand engines, all of which had been partially made ready for use immediately after the fall; but it finally gained the mastery, causing the loss of the lives of many persons imprisoned in the ruins, who would otherwise have been saved.

The general construction of the building will be understood from Plate III. Fig. 1 is a section through the centre of a beam, one side wall of the lower story, and one pillar. Fig. 2 is a section on a larger scale, at right angles to the preceding, through the top of a pillar, showing the mode of supporting the floors. Fig. 3 is a horizontal section of the side wall taken at the top of the beams of the floor forming the ceiling of the lower story. Fig. 4 is a horizontal section of the wall through the windows of either of the two lower stories.

The beams are ten feet apart, from centre to centre. The building is about eighty feet wide inside, the beams being in three lengths, sup-

* Since this passage was written, it has been ascertained that the main gas pipe and the metres were all at the northerly end of the building, which was the part that fell last.

ported at the joints by cast iron pillars, making two rows extending the whole length of the mill, and containing in all, fifty-four pillars in each story. Each beam is made of two timbers $7 \times 15\frac{1}{2}$ ins., with a space of $\frac{3}{4}$ in. between them; and, not proving stiff enough, the truss rods, $1\frac{1}{8}$ ins. diameter, were put on each side, after the building was erected. The three lengths of beams were connected together, over the pillars, by joint bolts, and the ends were anchored to the walls by irons $1\frac{1}{2} \times \frac{3}{4}$ ins., hooked on to the beams, and turned up into the wall about 9 ins., as represented in Fig. 1. On the beams was laid a uniform flooring of three-inch plank, dowelled together. On this was a thickness of one-inch boards, laid diagonally, and on this again were laid the floor-boards of Southern pine, $1\frac{1}{8}$ in. thick. Between the beams, the underside of the plank was sheathed with $\frac{7}{8}$-in. pine boards, forming the ceiling of the room below.

The system of pillars formed a continuous bearing of cast iron from the brick piers in the basement, to the roof. The pressure was transmitted through the floor beams by means of pintles, three inches in diameter, with flanges on the top, about $1\frac{1}{8}$ in. thick, to receive the bases of the pillars above. This arrangement is shown in Fig. 2. The bearing surfaces were left as they came from the foundry, except the ends of the pillars, which had been chipped off by hand.

The lower pillars rested on brick piers, from two to three feet in height, which again rested on stone foundations. A portion of the piers were first built one foot square, but this not giving a convenient bearing for the lower floor, they were enlarged by a course of half a brick thick all round them. (See Fig. 1.) This, of course, did not materially add to the strength of the piers to bear the pillars. These piers were of very well burned brick, laid in hydraulic cement, and none of them exhibit any signs of failure, although carrying fully 60 per cent. more weight than is deemed the safe limit by the best authorities.*

Most of the pillars were found broken after the fall, and the fractures disclose very great defects in the quality of the castings, being full of blow-holes, cold shuts, and thin places. All except those in the upper story supporting the roof, were hollow, and the fractures disclose that the cores were made in pieces insufficiently supported in the mould, and with no connexion between them for the escape of steam or gas, the iron in some places forming a diaphragm at the junction of the cores. These defective pillars were, undoubtedly, the primary cause of the disaster; and, the only wonder is that they should have stood so long as they did. They were furnished by the Eagle Iron Foundry in Boston, for $8·50 each, under a contract with Mr. Putnam, the agent of the proprietors.

Figs. 3 and 4 show the construction of the walls. Not considering the pilasters, they were of uniform thickness in all the stories, and contained air spaces, or vaults, as they are termed at Lawrence. The whole thickness was twenty inches, formed of an outer and inner wall of a thickness equal to the length of one brick, or $7\frac{1}{2}$ ins.; leaving an air space of 5 ins. The two walls were connected, on an average, every two and a half feet, the main connexions, which were opposite

* Morin, Aide Memoire, p. 332.

each beam, being a whole brick in width; the others half a brick each. In addition to this uniform wall, the two lower stories had pilasters, where the beams rested on the walls; they were 2 ft. 10 ins. wide, and projected into the rooms one brick or 7¾ ins. The mortar was composed of lime and sand of good quality, and apparently well made. The windows were unusually large, taking out of the brick-work, on the outside, a width of 4 ft. 9 ins., and on the inside, 5 ft. 1 in., and were 10 ft. high. The foundations of the building appear to have been sufficient; at any rate, the fall is in no degree to be attributed to any defect in them.

The following is the testimony of a witness, examined chiefly as an expert, before the jury of inquest, as taken down in brief by their clerk, and subsequently corrected by the witness as far as practicable, and subscribed by him in the usual form.

James B. Francis, being called and sworn, testifies as follows:—I reside in Lowell. I am an engineer employed by the various corporations there, and agent of the Locks and Canals Company. I have been employed as an engineer, by the Locks and Canals Company, rather more than twenty-five years; my connexion with the rest of the companies has been about fourteen years. During this time, I have been consulted in regard to the building of various mills. Have been called on to design various parts of the mills, principally relating to the foundations, the power, the wheel-pits, the main gearing, the strength of floors, and of pillars. My business has been mainly connected with the water power and the construction of mills.

The year before this mill was built, I was asked by Mr. Putnam, who was at the time Treasurer of the Boott Cotton Mills at Lowell, in relation to the pillars of a mill he was then intending to erect at Lawrence; what was said, I cannot now recollect, but I subsequently wrote him the following letter:

Dear Sir:—Assuming that the weight on the lower columns is the same as that on the corresponding columns of the Prescott Spinning Mill, a column seven inches in diameter and half an inch thick, would give ample strength, provided it could be properly cast. I should think it would be better to make it six inches diameter, and three-quarters of an inch thick, which gives an abundant margin for all contingencies. Of course, any column which has manifest imperfections should be rejected, but my calculation is intended to cover all ordinary imperfections. Of course the columns in the upper stories may be gradually diminished in size and thickness.

Very respectfully, Yours,

Lowell, Dec. 18, 1852. James B. Francis.

A diagram in the margin of the letter, indicates that a five story mill, eighty feet wide, was contemplated.

As now informed, the area of floor supported by each column in the Pemberton Mill, is fully double that supported by each corresponding column of the Prescott Spinning Mill; and, consequently, each column has to support double the weight at the Pemberton Mill, as at the Prescott. This, of course, is assuming that the weight per square foot of floor is as great at the Pemberton as at the Prescott, of which I suppose there can be no doubt.

At the Prescott Mill, the beams are eight feet apart, these are ten

feet apart; the space from column to column at the Prescott Mill, is sixteen feet, here nearly twenty-seven feet. The product of 8 by 16, equals 128 square feet; that multiplied by the number of stories (four), equals 512 square feet of floor, which is supported by each column in the lower story of the Prescott. In the Pemberton Mill, 26 ft. 10 ins., by 10 × 4, equals 1073 square feet, which is supported by each column in the lower story; the roof being also supported in addition at the Pemberton. The roof when loaded with snow, might be equal to one-third or one-half another floor. When I have made an estimate of the strength of columns, it has been based on what weight they would have to support. I always made an estimate, or have been furnished with one, for each particular case, when called on to calculate the strength of columns. As I recollect now, it has been my rule to make the columns of that size which would require a weight twelve or fifteen times greater than they will be required to support, to crush them.* When I say it would take twelve or fifteen times the weight to crush a column, I mean a column made and set as perfectly as the columns from which the rules are deduced.

I have in my possession, estimates which have been made of the weight per square foot of machinery on the different floors of mills.

By a column six inches in diameter, I should understand that this was the diameter at the middle. A column five and three-quarters inches in diameter, five-eighths inch thick, and twelve feet long, (which is said to be the size of the columns in the lower story of the Pemberton Mill,) according to the rule given by Hodgkinson,† has a breaking weight of two hundred and thirty-one tons. A column, five and a half inches in diameter, five-eighths inch thick, and twelve feet long, by the same rule, has a breaking weight of two hundred and three tons

* At first sight, this appears an excessive allowance, but the following considerations will show that it is no more than is required for security.

Hodgkinson's formula (Philo. Trans. 1840.) is deduced from pillars with flat ends, very carefully fitted, so that the pressure would be uniformly distributed. He found that when a pillar is so fixed that the pressure is in the direction of the diagonal, its strength is diminished to one-third; and, it is highly probable, that in a pillar in which the core is not central, this would not be the weakest position. As pillars are ordinarily fitted and put up, nothing else could be safely relied on, except such an unfavorable position. We must therefore assume that the breaking weight is diminished to at least one-third, by imperfections in the bearing surfaces.

The pillars from which the formula is deduced, were cast with great care, and were either perfectly straight or were rendered so in the lathe. They were of a superior quality of iron, (Low Moor, No. 3.) Their dimensions were much less than are usual in practice. It is well known that iron cast in large masses is of less strength, both tensile and crushing, than when cast in small masses, and, in long pillars, both these qualities are essential to their strength. Again. The breaking weight found by experiment, was one that would cause fracture in a short time, in a pillar not in a state of sensible vibration; whereas, in practice, time is unlimited, and the vibration (at least in mills) very apparent. Finally, the formula is an empirical one, and consequently not to be trusted implicitly much beyond the limits of the experiments on which it is founded. It is impossible to estimate with precision the diminution of strength in practice due to these causes; all must agree, however, that one-half is not an excessive allowance. Adopting this, and combining it with the preceding one-third for imperfect bearing at the ends, we have one-sixth of the breaking weight, as computed by the formula for pillars with flat ends, as the breaking weight of cast iron pillars, as ordinarily made and set up.

So far we have no margin for safety; what this should be, depends in part upon the amount of mischief that would be caused by a failure, and also upon the degree of confidence in the founder and fitter-up. Two, two and a half, or even three times, could not be considered excessive. These numbers combined with the preceding one-sixth, gives a breaking weight *by the formula*, twelve, fifteen, or eighteen times greater than the actual weight to be supported.

† Experimental researches on the strength and other properties of cast iron by Eaton Hodgkinson, London, 1846, p. 334. The formula given for hollow pillars, whose ends are flat and firmly fixed, is

$$\text{Strength in tons, (of 2240 lbs.,)} = 44{\cdot}3 \times \frac{D^{3.6} - d^{3.6}}{l^{1.7}}$$

from which we deduce

$$\text{Strength in tons, (of 2000 lbs.,)} = 49{\cdot}61 \times \frac{D^{3.6} - d^{3.6}}{l^{1.7}}$$

A column, five and three-eighths inches in diameter, five-eighths inch thick, and twelve feet long, has, by the same rule, a breaking weight of one hundred and ninety tons. These calculations are made from pillars accurately set; the rule was deduced from a number of columns of various sizes, made of good iron, of one uniform kind, and mostly cast in dry sand vertically, and all pains taken to get the cores exactly central, but they did not succeed in many cases.

I selected several of the experiments given by Hodgkinson, and calculated what the pillars should bear by the rule, and compared it with what they did bear by experiment. I selected a column, in which the thickness was uniform all round at the place of fracture, as a standard; calling the strength of this 100; another, where the metal was twice as thick on the one side as on the other, the strength was 98; another, in which the metal was five times as thick on one side as on the other, the strength was 84. But this should not be taken as the true representation of the fact, in general, as the experiments were too few; they, however, indicate that there is not so much difference in strength from this cause, as might be supposed.

If that capital* had been of good iron, five-eighths of an inch thick, and making part of a column five-eighths-inch thick, it is immaterial if it is only stronger, which I think it is, than the weakest part of the column, which is usually half way up. The fact of the bulging of the capital does not add nor detract from the strength of the column, provided it is still stronger than the weakest part of the column, which I believe it is.

The breaking weight of a pintle, with a flanch, seven inches in diameter, one and one-eighth inches thick, on the top of the pintle three inches in diameter, with a column resting on it, five and three-fourths inches in diameter outside, and half an inch thick, placed concentrically with the flanch and pintle, the top of the flanch being uneven, as castings usually are, I think would not be far from forty-five tons. The safe weight, in my opinion, would be one-fourth part of this; one-fifth would be safer; certainly not more than one-third of this would be safe. It does not require so large a margin for security as hollow columns. If on the same pintle a pillar of six inches had been placed, I should have considered it weaker. I do not think that the fact of heavy timbers being under the flanch of the pintle made it any less liable to break.

Estimating the weight as follows:

Machinery on second floor, as given by Mr. Chase,							275	tons.
"	third	"	"	"			150	"
"	fourth	"	"	"			100	"
"	fifth	"	"	"			75	"
Shafting, as given by Mr. Burke,							125	"
500 people at sixteen to the ton,							31	"
Stock on upper floors, as given by Mr. Chase,							65	"
Piping and columns, estimated at							60	"
4½ floors, estimated at 25 lbs. per square foot,							1260	"
				Total,			2141	tons.

* See Plate, Fig. 2.

Journal Franklin Institute

Details of Construction of the Pemberton Mills

Fig. 1.

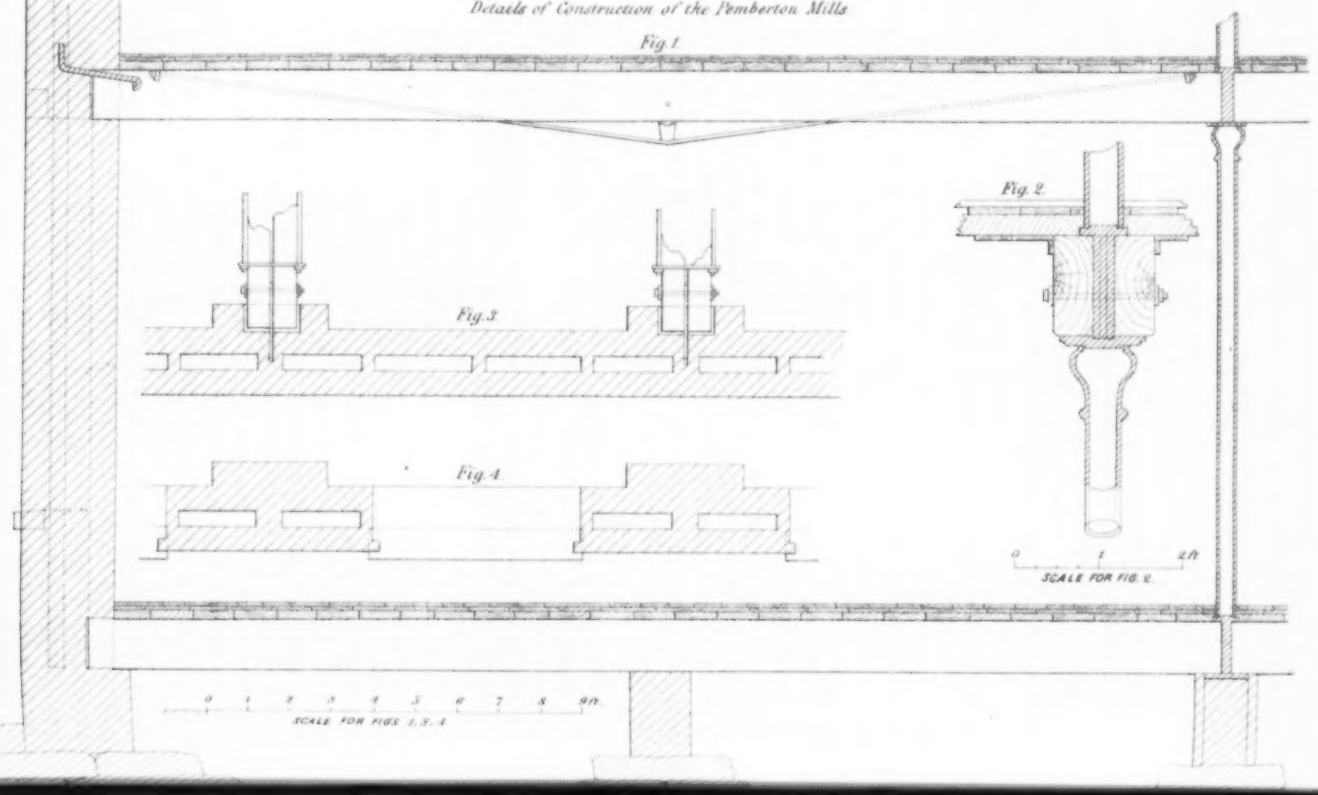

Fig. 2.

Fig. 3.

Fig. 4.

One-third of this weight rests on the side walls; reckoning two columns for the ends of the mill, making in all equal to fifty-six columns, and dividing the remaining two-thirds of the whole weight by that number, gives about twenty-five tons on each of the lower columns. This would be between one-ninth and one-tenth of the breaking weight, as calculated by Hodgkinson's rule, of the columns in the lower story.

Provided the columns are as perfect as columns are usually made for mills in this neighborhood, I cannot call this unsafe, although not so large a margin of safety as I would recommend; but as the columns turn out to be on examination, I consider it entirely unsafe. The weight of twenty-five tons on the pintles, being more than one-half of the calculated breaking weight, I should consider unsafe, even if all the castings were perfectly sound. If these columns had been as perfect as they ordinarily are, and a pintle had broken, I think it would not have caused the mill to fall. There would have been a shock, equivalent to a great additional weight; but, if the column came down on the beam, as I suppose it would, and did not crush through, I think it would not have endangered the whole structure.

If this plan of pintle had been brought to me, I should have gone through a similar calculation to that I have here, and think I must have arrived at a similar conclusion.

I think there ought to have been another row of columns; twenty-seven feet is too great a span as we get materials here.

If I were to build a thin vaulted wall, I should put a portion of cement in the mortar. All vaulted walls which I know of, except these, have cement in the mortar. I should prefer solid walls, if laid in lime mortar, without cement. Our practice at Lowell, has been to build thicker walls. I dont think any disaster would have followed from the walls, if the interior arrangement of the mill had been good. If the walls had been as thick as our Lowell walls, and several of the pillars had given way near together, I should have expected the walls to fall. The fact of the walls remaining true to the lines, and the building free from cracks, would give confidence in the strength of the walls, and the strongest reason to think that the trouble originated from the inside. The fact of the windows being so large, would render the wall weaker than if they were smaller. My opinion of the original cause of the disaster is, that it was something connected with the pillars; but, if the supports generally had been sufficient, and the walls stronger, the giving way of one support would not have caused the whole structure to come down. The fact of cracks by the side of the chimney, would not lead me to distrust the strength of the mill, because such cracks are to be expected where a large and lofty chimney is joined to a building.

As far as I know, it has not been a custom to make any systematic examination of the pillars at Lowell; the parties who furnish the pillars are considered responsible for them. I don't know that I ever heard of an iron column breaking before these. If the columns were coming from persons whom I knew nothing about, and I had any suspicions, I think they would be looked after more closely. I think

some columns have been objected to on account of their crookedness. The fact that these columns have stood six years, poor castings as they are, gives me great confidence in the safety of iron columns as usually made for mills. JAMES B. FRANCIS.

JAMES B. FRANCIS, *re-called.*—If the original cause of the disaster was the failure of a column or pintle, the weakness of the walls greatly increased the danger of the whole mill falling, as it did. The flanch of the pintle being an ordinary rough casting, and the bottom of the column not accurately fitted to the casting, it follows that the weight could not have been uniformly distributed all round the flanch, and in many cases, most of the weight must have been on two points; and in some cases, I have no doubt, half the weight was on a single point, or on a very small part of the surface of the flanch; and in making my calculation of the breaking weight of the pintle, I have so assumed it to be.

The particular circumstances in each case govern the foundation walls for mills. A reason why the foundations in many of the Lowell mills are so deep, is, that the wheel-pits are under the mills; where the wheel-pits are not under the mills, it would not, generally, require the foundations to go so deep.

Most of the mills at Lowell are four stories and a basement in height; four stories in front, five stories on back; the thickness of the brick walls in the basement, is usually two feet; the next two stories, twenty inches, and the next two stories, sixteen inches; solid walls laid in lime mortar without pilasters. Windows are about three and a half feet wide and six feet high. The floor timbers are eight feet apart and about thirteen by fifteen inches, not spliced. Floors are of three inch plank with a boarding above and sheathing below, making in all about four and three-quarters inches. The width of the mills inside is from forty-one to forty-four feet with one row of columns. Length of mills inside, about one hundred and fifty-three feet. Some of the new mills are of quite different dimensions from these. Think the walls of mills with deepest foundations, laid with common dry walls, are liable to crack the most.

I looked at some parts of the foundations of the Pemberton Mill, and found no perceptible settling. The fact that the mill stood so long without injurious settlement, is good evidence that the foundation was sufficient. The soil here is very similar to that at Lowell, and I should think there would be no unusual difficulty in getting good foundations.

JAMES B. FRANCIS.

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*Steel Bell Casting at Sheffield.**

A large number of persons lately assembled at the works of Messrs. Naylor, Vickers & Co., Millsands, to witness the casting of the largest steel bell which has yet been produced in Sheffield. The bell, which was designed by Mr. Roddewig, the engineer of the firm, is to be used as a fire-alarm bell in the city of San Francisco. A large iron vessel, plugged at the bottom, says the *Sheffield Independent*, was placed in

* From the Lond. Builder, No. 880.

the pit, above the mould, to act as a funnel, and the molten steel was poured into it from the crucibles. The moment that part of the process was finished, the plug was drawn from the bottom of the funnel by means of a crane. The fiery liquid then ran into the mould in a copious and uninterrupted stream, and the work of casting was complete. When the metal was sufficiently cooled to permit of an examination, it was found that all had gone right, and that the casting was perfectly sound. The weight is 2 tons 12 cwt., or 5824 lbs., and the dimensions are,—Height, 5 feet 3 inches; diameter at the mouth, 6 feet 2 inches; thickness at the sound-bow, (where the clapper strikes,) 4¼ inches. Messrs. Naylor, Vickers & Co. cast their first bell in 1855, and have since turned out 1300. Steel is considerably cheaper than "bell metal," and also stronger, so that a much smaller weight suffices for any required result, thus making the difference between the price of the two kinds of bells even greater than is represented by the difference in the cost of the material per weight.

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*Improvements in the Manufacture of Umbrellas, Parasols, Hats or Hat Covers, Caps, Capes, Coats, Mantles, Dresses, Gloves, and other similar articles.** STEPHEN BARNWELL and ALEXANDER ROLLASON.

Collodion and castor oil have received a new application. Messrs. Barnwell and Rollason use the mixture for making silks and other woven fabrics water-proof. Their manner of proceeding is as follows: "Assuming the material under operation to be silk, we take collodion and mix it with vegetable oil, such as either hemp-seed, rape, olive, almond, nut, poppy, castor, cotton, or linseed oil in the purest possible state, and we find that such oils when mixed with collodion, undergo a change upon being subjected to heat, and this change or decomposition is highly advantageous in the subsequent processes to which the silk will be applied. The mixture of collodion and oil is spread or poured upon plates or cylinders of metal or glass, and before it is quite set the silk is laid or rolled over it and immediately removed, bringing away with it a thin film of collodion and oil. The silk thus coated is now removed to a stove or drying oven and submitted to a heat of 100° to 300° Fahrenheit, by which the mixture undergoes the before named change or decomposition, and the result is, that a slightly glazed appearance is imparted to the silk, which is at the same time considerably strengthened or thickened, and may be rendered almost or quite opaque by the mixture of coloring or thickening matter with the collodion and oil. A thin silk is thus rendered equal in strength to a more costly one, and the quality of imperviousness to water, which the material possesses in a high degree, will be of service."

The patentees prepare their collodion with gun cotton or with xyloidine made from hemp, flax, jute, straw, saw-dust, or starch, which they dissolve in any of the solvents of gun cotton and mix with any of the oils before-mentioned, adding only so much of the oil or mixed oils as will be freely taken up by the solution. If they desire the

* From the Chemical News, January, 1860.

coated silk or other fabric to be soft and pliable in its nature, they add a small quantity of animal oil to the solution. The proportions the patentees use for coating silk are 30 parts of the xyloidine dissolved in *about* 300 parts by weight of ether, with 100 parts of spirits of wine, with which is mixed from 75 to 100 parts of vegetable oils. This solution is allowed to evaporate in a still until it arrives at such a density that it will only just flow evenly over a glass plate, so as finally to leave a substantial film behind it.

If the patentees can make some light and inexpensive fabric waterproof, and at the same time soft and pliable, it would be extensively used by surgeons. Oiled silk is expensive, and the oiled calico and gutta percha tissue, sometimes used in its stead, lack the softness and pliability desired. The article we have suggested is greatly desired in our large hospitals.

For the Journal of the Franklin Institute.

Particulars of the Steamer Peruano.

Hull built by J. Westervelt & Sons. Machinery by Morgan Iron Works, New York. Owners, Chas. A. Denion & Os.

HULL.—	
Length on deck,	180 feet.
Breadth of beam (molded),	29 " 3 inches.
Frames—molded, 12 ins.—sided 7½ ins.—apart from centres, 30 ins.; strapped with diagonal and double laid braces, 4½ × ⅝-in.	
Keel—13 ins. deep.	
Bulkheads,	Three.
Depth of hold, to spar deck,	11 "
Length of engine and boiler room,	65 "
Draft, forward and aft,	7 "
Tonnage,	560.
Area of immersed section at load draft of 7 feet,	170 sq. ft.
Masts, two—Rig, schooner.	
ENGINE.—Vertical beam.	
Diameter of cylinder,	44 inches.
Length of stroke,	11 feet.
Maximum pressure of steam,	25 lbs.
BOILERS.—Two—Return flued.	
Length of boilers,	24 feet.
Breadth "	5 " 6 inches.
Height "	5 " 2 "
Number of furnaces,	2 in each.
Length of grate bars,	6 " 9 "
Number of flues,	10.
Internal diameter of flues,	12, 15, and 16 ins.
Length of flues, { above,	20 "
Length of flues, { below,	14 "
Diameter of smoke pipe,	4 " 10 "
Height "	32 "
PADDLE WHEELS.	
Diameter over boards,	27 feet 6 inches.
Length of blades,	7 "
Depth "	22 "
Number "	24.

Remarks.—One independent steam, fire, and bilge pump. Cabin on spar deck. Date of trial, February, 1860. C. H. H.

For the Journal of the Franklin Institute.

Collection of Observations on the Day-light Meteor of Nov. 15, 1859, *with remarks on the same.* By BENJAMIN V. MARSH.

(Continued from page 210.)

Newburyport, Mass.

Dr. H. C. Perkins, in a letter to Prof. Henry, says, "Miss A. Brockway saw it, about 8° or 10° high, moving towards the horizon in a S.S.W. direction. It was of a brilliant yellow color, and resembled a rocket."

Alexandria, Va.

Caleb S. Hallowell, Principal of the High School, was in the open air in company with his students, several of whom saw the meteor. In a notice published at the time they say, "The sun was shining brightly, notwithstanding which, the light given out by the moving mass was brilliant in the extreme. It appeared in the east about 45° above the horizon, and ranging from thence in a *northerly* direction, obliquely towards the earth. In appearance, it most resembled a cone, moving base foremost, with an entire length of about 10°, the edges being of a silvery lustre, and the centre red."

Recently, Mr. H. says, that Abram Martin, a student particularly well qualified for such observations, "was, fortunately, standing perfectly still, with the meteorite in full view during its entire visibility; and he seems completely to have daguerreotyped its path and its appearance on his mind. By my direction, he made at the time a careful note of the spot where it fell; and, as to the point in the heavens from whence it originated, he, on two *independent* and *distinct* trials, pointed the telescope of the theodolite very nearly to the same spot, as given below.—

	1st obs'n.	2d obs'n.	Mean.
Apparent altitude at moment of appearance, . .	40°	39½°	39¾°
Azimuth " " .	N. 83 E.	N. 85 E.	N. 84 E.
Apparent altitude at moment of disappearance behind houses, ...	11°	10°	10½°
Azimuth " " . .	N. 77 E.	N. 76 E.	N. 76½ E.

"The path of the body was slightly curved, being convex towards the earth. It appeared as a cone with a flat base of about half the diameter of the moon, the central part of the train being red, and the edges intensely bright yellow, nearly as bright as the sun, the brightness at the edges being more intense than at the centre."

Petersburg, Va.

T. C. Garrison says, "When first seen, about 30° above the horizon, descending in a vertical line, throwing off brilliant corruscations, resembling scintillations from molten iron. The body of the meteor resembled in color, iron of a red heat. The scintillations were of a dazzling brightness, and resembled a shower of sparks of large size. It seemed to fall to the earth within 500 yards of my position. I saw it but for a moment. Its brilliancy was intense. Time about 9·20, but my watch somewhat uncertain."

Mr. G. sends a sketch of the relative positions of the meteor and

the sun, which shows the elevation of the meteor, when first seen, to have been about one-third greater than that of the sun.

At Beasley's Point, N. J.

Samuel Ashmead says, "The day was calm, atmosphere perfectly clear, and not a cloud to be seen. A sudden flash of light exceeding that of the sun (which was shining brightly) was soon followed by a terrific rattling noise immediately overhead. I was out of doors at the time, and could compare the noise to nothing else than the discharge of a thousand cannons in the shortest space of time, *without any two guns exploding at the same moment.* These explosions were *sharp* and *distinct*, not like the prolonged roll of thunder, and continued at least one minute. The course of the meteor was rapid from north-east to south-west, leaving behind a curling track of a smoky or light cloudy appearance, which in a few minutes melted away in the atmosphere. According to the opinion of several persons, the interval between the flash and report was about one minute."

Mr. Ashmead further says that the form of the cloud was oblong, its diameter perhaps twice that of the moon, and its length many times greater—the western end more distinct than the eastern. The sound which first reached him, was a kind of *fluttering* or *rushing sound*, comparatively faint, conveying the impression that a horse was running away; that he looked up, and just then came the crashing thundering sound, already described.

At Dennisville, Cape May County, N. J.

Dr. M. Beesley says, "I was reading in my house about half-past nine o'clock, when the report commenced, which was similar to that made by a chimney when burning out at full blast. I immediately went out of doors, and there discovered that the noise was directly overhead, and might have been compared to a train of cars passing rapidly over a rough road, with incessant detonations which seemed to be of an explosive character, much resembling a distant park of artillery.

There was a small cloud or belt of white smoke left in the train of it about 5° N. W. of the zenith, the atmosphere being perfectly clear at the time, and it passed off in a N. E. direction.

The detonations and rushing sounds lasted something over a minute, when, *after an entire suspension*, they were faintly repeated again, far off in the N. E.

It created very general alarm throughout the country. Numbers saw a flash of light precede the report. It was so near us, that dishes were moved standing upon stoves, and sash trembled, and the first thought that struck me, on going out of doors, was, that an earthquake was in progress near us. The detonations, from all the information I can get, were louder and more apparent here than at any other place. In fact, they were absolutely alarming, many people quitting their work in consequence of it, and one man went home and told his wife, that time was nearly at an end, for the Angel Gabriel had given the first blast of his trumpet."

Judge Goff, 5 miles west of me, says, "The smoke was at an elevation of 60° or 70° eastwardly." Samuel Springer of Dyas Creek, 8 miles S. W., says, "It was north-westward—elevated about 60°—and

on the sea-shore road, 5 miles east, I learn it was about 60° westwardly—and at this place, it was about 5° N. W. of zenith. This cloud of smoke, or rather, it had the appearance of steam as it passes from the pipe of a steamboat, occupied but a small space, and that near the zenith."

Dyer's Creek, Cape May County, N. J.

A. Smith says, "Several saw clouds of a roundish form, others, columns of smoke as that rising from the firing of artillery. The noise was great, lasted two or three minutes, shaking the house I was in so much that the shutters jostled on the hinges. The sound was very much like that of a wagon full of empty barrels driven furiously over a rough road, or a train of cars passing over a bridge. Horses were frightened and cattle huddled together in the fields. Some persons saw a flash—I saw it in the house about three minutes before the report. It was similar to the reflection of the sun from a looking-glass. The smoke was seen by many, in a north-east direction, elevation 75° to 80°. The form is differently stated. Some say it was roundish; others, that it rose in form of columns, three in number. The clouds were small; seemed to diverge as they shot up. The noise was at no time very much louder than at others, yet it began by growing gradually louder, and then, as gradually grew fainter."

Fishing Creek, Cape May County, N. J.

L. Cummings says, "Heard a low rumbling sound in the north-east, which gradually grew louder, resembling thunder. Saw, in the direction of the sound about 60° above the horizon, a round body twice the size of the full moon, and very near the color of the moon in the day-time, having something like a tail pointing towards the sun. I first thought it a balloon. The noise changed from a rumbling to a crackling sound like the flapping or fluttering of a loose sail in a heavy wind, and gradually ceased with the flapping sound. The body looked like smoke and soon began to change its shape, break in pieces, and roll away to the eastward. When first seen, it appeared to be moving slowly in a north-east course. In two minutes all was gone. Some saw a bright gleam of light pass through the room before the rumbling began. The sound appeared very heavy, causing windows to shake, and other bodies seemed to jar and tremble. It was not over the bay. Many thought their houses or chimneys were on fire, and others thought horses were running away."

Mouth of Antuxet, Delaware Bay.

Capt. Harris, of the *Miller's Daughter*, saw nothing; heard a noise about east. It lasted about three minutes. At first resembled the sound of a cannon in a calm cloudy morning, being a kind of prolonged roar and not a sudden explosion; afterwards a kind of quivering noise; finally pronounced it an earthquake. Resides at Maurice River Cove. The oystermen there told him they saw a ball of fire as large as a barrel. That it burst and balls of fire flew all around. On shore people thought chimneys on fire. Some within doors saw a bright flash on the bricks.

Egg Island.

Vessels shaken so much that one captain thought his vessel was grazing bottom. Sounded and found deep water. Saw a longish cloud east or north-east, at an elevation of, say, 20°. Roaring noise.

Maurice River Cove.

Many captains of oyster-boats there heard noise in easterly direction. Vessels shaken. Nothing seen or heard over the bay.

East Point, Cumberland County, N. J.

J. H. Zane was in a field one mile north-east of East Point. "At first thought it was thunder. Looked, but saw no cloud or fire. Sound came from north-east or perhaps a little further east—was quite loud, seemed near the earth, very much like thunder. Some of my neighbors saw fire and smoke three minutes. I didn't hear it three minutes, scarcely two."

Four miles west of Dover, Del.

P. F. Nickerson says he was in a carriage. His wife saw the meteor and called his attention to it; but he only saw "the trail as a silvery vapor or smoke," direction due east. The column was nearly or quite vertical, its base 20°, and its top 40° above the horizon. "Of a silvery appearance, and disappeared at the bottom end first as smoke would, only it did not spread or ascend, but disappeared in the distance; was visible 8 or 10 minutes; heard no sound, owing perhaps to the noise made by the carriage."

Lewistown, Del. Robert West sends the following:

L. D. Martin, near Lake Newbold, heard noise ¾ to 1 minute; supposed a ship had let go her anchor, the noise resembling that of a heavy chain. Direction, that of Cape May. Saw no light. His children saw "an instantaneous light, like the reflection of the sun on glass or bright metal."

George M. Cooper, Lake Newbold, was at work in his field. First thought it thunder; then, seeing no cloud, concluded it the wheels of a large steamer; thought of an earthquake. Direction, that of Cape May.

A lady 1½ miles south-west of Lewistown, was riding north-east towards town; saw a bright light enveloped in smoke—thundering or loud rumbling noise at same time. Was greatly alarmed, so that she stopped at the house of a friend, near by.

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From the nature of the case, most of the preceding observations are necessarily very uncertain, but the discrepancies are scarcely greater than might fairly be expected. It is well known that persons unaccustomed to such observations, are pretty sure greatly to overestimate altitudes, and underrate zenith distances; and it will no doubt be found that most of the altitudes given above will require reduction. The observations as a whole, seem to me best represented by the following, which are, of course, only rude approximations, but may perhaps serve to pave the way for something more exact.

1. The inclination of the meteor's path to the vertical, was probably about 35°, and the direction of its motion nearly west. The observations at Medford and Petersburg, indicate a much more southerly movement, but those at Washington, Alexandria, and Dover, require it to have been almost due west.

2. The column of smoke was near 1000 feet in diameter, and its base was vertical about 4 miles north of Dennisville, at a height of near 8 miles, which may be assumed to be the approximate position

of one point in the meteor's path. The height is inferred not merely from the angular elevations of the smoke as seen from different points, but from the interval between the flash and the report, as observed at Beasley's Point.

This position assigned to the base of the cloud, from local reports, coincides pretty nearly with that indicated by distant observations.

At New Haven, latitude 41° 18′ 18″, longitude 72° 55′ 10″, at an elevation of 6°, the bearing was S. 35° 34′ W., and at Alexandria, latitude 38° 49′, longitude 77° 4′, at an elevation of 10½°, it was N. 76½° E. These directions meet half a mile west of Dennisville in latitude 39° 11½′, longitude 74° 50½′. The line from New Haven having a vertical height at this point of 22½ miles, and that from Alexandria, 24½ miles. Continuing the path, as observed at Alexandria, down to 9½° elevation, we have corresponding azimuth 76¼°, and the lines then meet half a mile north-west of Dennisville at a height of 22½ miles; but this makes the nearest point in the meteor's path 24 miles from Beasley's Point, and consequently, the interval there between the flash and the report two minutes instead of one, as observed. Besides, the observations on the smoke show pretty clearly that the minimum height at Dennisville could not have exceeded ten miles. We must, therefore, conclude the meteor's actual position to have been several miles east of that indicated by these distant observations.*

3. On the above supposition, the meteor's path would reach the earth near Hughesville, on the north-western boundary of Cape May County, in which vicinity, or perhaps still further west, it is probable that the meteor or some of its fragments will yet be found.

4. Some observers must have seen the meteor at a height of more than 100 miles; and, to have completed its path within their estimates of time, it must have had a velocity of from 30 to 50 miles per second.

The extreme shortness of the time occupied in its flight, is proved not merely by the estimates of several observers, but by the failure of people in the vicinity of the explosion to distinguish the source of the sudden flash of light seen by them, and by the impression of even the most distant observers, that it fell very near to them.

5. The sound was explosive, and *not* caused by the falling in of the air after the meteor. In the latter case, it must have been continuous and uninterrupted; but the testimony of Dr. Beesley, and others, shows that it ceased entirely and then began again. Supposing the meteor to have been a stony mass, we may, perhaps, consider the explosion to have consisted of a series of decrepitations caused by the sudden

* J. P. Pirsson, while passing along Broadway, directly opposite Bond Street, New York, saw the meteor, and immediately stopped to fix its bearing.

In a notice published at the time, he says, "It disappeared behind the tall iron warehouse opposite St. Thomas' Church, and in a line, from my position, with the white sign painted upon its north wall, near the front," its inclination to the vertical being 30° to 40° westward.

Since the above was in type, Hugh D. Vail has visited the spot with Mr. P., and by measurement with a theodolite, has ascertained that the apparent elevation of the point of disappearance was 8° 40′, and the angle made with Broadway, about 9° 2′.

According to the "Harbor Commissioners' Map," Broadway runs S. 32° 31′ W., which makes the bearing of the meteor S. 22° 29′ W.

This line crosses the parallel of Hughesville (39° 15′) in longitude 74° 49¼′, at a height of 18·7 miles, and reaches that of 39° 11½′, in longitude 74° 50½′; so that the lines from Alexandria, New Haven, and New York, all pass exactly over this spot, at the heights of 24½, 22½, and 18¾ miles, respectively; which would bring the meteor to the earth at the distances of 17, 15½, and 13 miles westward from this point.

Supposing it to have been on the parallel of Hughesville, this observation makes it reach the earth 8 miles west of that village.

expansion of the surface, the whole time of flight not being sufficient to allow the heat to penetrate the mass. At the forward end these explosions would take place under great pressure, which may account for the loudness of the sound.

6. The estimated duration of the sound at Beasley's Point, was not less than one minute; indicating that the most distant point of the explosion was not less than 12 miles further from that place than its nearest point. Comparing this with the position of the assumed path, we find, that during the explosion, the meteor must have traveled 15 or 20 miles, occupying about half a second of time.

7. The explosions were very numerous, arranged in two series, the whole occupying only ½ second of time; but the individual sounds were distinguishable, because of the different distances they had to travel to reach the ear. The velocity of the meteor being more than one hundred times that of sound, the reports must have come in the order of distance, and *not* in the order of their occurrence, causing the end of the explosion to be heard before the beginning. The faint rushing sounds first heard by Mr. Ashmead, must have had their origin below the explosion, and been caused by the flight of the fragments towards the earth. If the direction of this *first faint* sound could be indicated by persons further west, it might serve to point to the place where fragments fell.

8. The meteor lost its luminosity with the explosion or shortly after, and hence was not seen by persons in Cape May County and vicinity, it being too much overhead to come within the ordinary range of vision, and the time of flight being too short to allow them to direct their eyes to it after seeing the flash.

If the heat be due to the resistance of the air, it must be principally developed at the surface of the forward half of the meteor. Consequently, most of the explosions must occur there, and the force of each be directed backward, tending to check the velocity of the mass. In fact, we may perhaps consider the series of explosions to be merely one of the forms of the atmosphere resistance. This must increase rapidly with the density, although it may be insufficient to account for so great a reduction of speed as would entirely destroy the luminosity of the meteor before it reached the earth.

9. From the tremendous force of the explosion, and from the fact that this meteor was seen by persons who were not within two hundred miles of any part of its path, as at Salem, Mass., and Petersburg, Va., we must certainly conclude that it was of very considerable size; but we seem to have no data for any approximation to its actual dimensions. It was certainly heated to a most intense brightness, and the experiments of Prof. J. Lawrence Smith, detailed in *Silliman's Journal*, Vol. xix, fol. 340, 2d series, in which he found that a piece of lime, less than ½-in. in diameter, in the flame of the oxyhydrogen blowpipe, had, when viewed in a clear evening, at the distance of half a mile, an apparent diameter twice that of the full moon, show conclusively that no reliance can be placed upon calculations founded upon the apparent diameter of bodies in a state of incandescence.

10. The apparent form of the meteor—that of a cone moving base

foremost—may have been due to its great angular velocity, combined with the effect of irradiation above referred to. The impression made upon the eye by the incandescent body itself, would doubtless be greater than that made by the sphere of light surrounding it. Consequently we should continue to see the body itself after the impression of the mere glare had faded away; so that the apparent diameter of the end of the tail may represent the actual angular diameter of the body.

11. The invisibility of the meteor to persons at Philadelphia and vicinity, was no doubt due to the position of the sun, the direction of which there coincided with that of the meteor.

Philadelphia, February, 1860.

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*Facts Relating to the Use of Zinc Abroad.**

The reputation of zinc for roofing is not good in England. Abroad the material appears to be used very largely and successfully. To ascertain the reason for this difference the Vieille Montagne Zinc Mining Company have recently commissioned Mr. James Edmeston to inquire into the matter. His report, which was read at the Institute on Monday evening last, and is about to be published, is now before us. The Vieille Montagne Company is a very extensive undertaking:—

"In the seven large smelting establishments in Belgium and Prussia, comprising 230 furnaces, 29,000 tons of spelter are produced, and 23,000 tons of sheet zinc are annually made, besides about 7000 tons rolled at mills which are not the property of the company. In the three establishments for making oxide of zinc, about 6000 tons of oxide are annually manufactured. The company is besides a large purchaser of spelter in the market.

"It is said that the general consumption of spelter throughout the world is about 67,000 tons per annum, of which about 45,000 tons are made to take the shape of rolled sheets, and these are estimated to be applied as follows, each quantity being somewhat below the truth:—

	Tons.		Tons.
Roofing and architectural purposes,	23,000	Domestic utensils,	12,000
Ship sheathing,	3,500	Stamped ornaments,	1,500
Lining packing-cases,	2,500	Miscellaneous,	1,500
			44,000

Fifteen years ago the quantity used for roofing did not exceed 5000 tons: none was employed for ship sheathing or lining packing-cases, and the stamped ornaments in zinc date only from 1852."

The process of manufacture is simple: the calamine (carbonate of zinc) is first calcined, by which it loses about 20 per cent. of its quantity: it is then ground in a mill and mixed to the extent of one-third of its bulk with powdered coal, to assist the smelting. The whole being much moistened, this mixture is put into the smelting-pots, and these at six o'clock every morning are placed in the furnaces. At six o'clock in the evening, that is, in twelve hours, the smelting is complete. The metal is drawn out and run into metal moulds: it then goes into the rolling-house, and is again melted and re-cast in a metal mould to produce ingots of the proper size and weight for the required gauge of sheets to be rolled: this second melting is also desirable to obtain proper purity.

In the first place, purity in the metal to be used for building purposes is important: if there be much impurity no after-care will be of any avail. For ship sheathing—and zinc is now very largely used for this—perfect purity is essential, for it becomes immersed in a down-

*From the London Builder, No. 884.

right galvanic bath; and if iron be present in even a small quantity, or lead, it would quickly destroy itself. This is not so much the case in roofs, but purity is most desirable; and impurity may exist to an extent sufficient to spoil the best-constructed roofs, and in many cases has done so beyond doubt.

Mr. Edmeston made inquiries in England previous to going abroad, and all the replies were condemnatory, with two exceptions.

"Some instances of failure were brought before me, and these were mostly as follows:

"Crumbling to pieces; black spots appearing, supposed to be the effect of London atmosphere; holes and wearing out of the metal in a short time;—all these would arise from impurity in the metal, or from contact with iron. Then,

"Cracking in places; soldered joints parting; drips or joints failing in flats; tendency to buckle and to have an untidy appearance in consequence, and general unsoundness of the work;—all these would arise from bad construction."

Abroad, amongst the failures, he mentions one:—

"But, even if the zinc contains no iron, the contact of iron, where a little confined damp may exist, will be quite as injurious. I cannot find that this is understood here: iron nails are commonly used for boarding under the zinc, and if a nail head is in contact, and there is damp, in three months a hole will be eaten through. Generally speaking, for the best roofs on the Continent, zinc nails are used for the boarding, and all iron work, where necessary, and if used at all, is galvanized. Or where iron nails are used for boarding they have small heads, and are hammered well into the wood so as to be buried, and a little cement or stopping is frequently rubbed in over them. Practice has found that the nails thus used rarely do any mischief, and as the zinc nails require certain care and take more time, and are dearer than the iron, I found that in Paris, at all events, the iron were used frequently, but always with the above precautions.

"I could not discover that the contact of lead was injurious, but it is considered to be better avoided.

"Impure zinc being brittle will crack when turned up against the rolls, or it will break off entirely, and the builder who saves something in first cost, is quite likely to lose more in the end from waste.

"The second set of defects to which I have alluded, and other modifications of them, will be referable to ignorant construction: they none of them exist where proper knowledge has been exercised in this respect, and the one object to be kept in view is to permit *perfect freedom to the sheets*, to confine them no where, and to separate lengths of guttering, and any other portions of a roof requiring to be made in long pieces, as much as possible.

"Eaves gutters should be made in short lengths, bent in the direction of the way in which the sheet has been rolled and soldered; the solder put between the sheets and one sheet lapping over the other; they must not of course be screwed to the rafter's feet—a practice, by the way, which occasions a constant failure in the joints of iron eaves gutters. Wherever a down pipe comes, there should be a stopped end in the gutter, and the gutter should never be continued longer than possible in one piece: where it is laid behind a parapet, as in all the new and magnificent buildings in Paris, a separate piece of flashing will disconnect it wholly from the sheeting on the roof. For guttering, the gauge used should be increased in proportion to length, say No. 14 for 10 feet, No. 15 for 20 feet, and so on up to No. 18. There should be a proper substance in all cases. No. 14 is ample for London; in Germany it is customary to use a less thickness.

"The choir of the cathedral at Cologne is covered with Silesian zinc. The old lead was defective and was removed, and the zinc substituted by Herr Zwirner, in 1829. The gutters are zinc: it is laid in the old way without wooden rolls or fillets, as is the custom still in Germany. Herr Zwirner, the architect to the Royal Commission, informs me 'that zinc is now commonly used for roofs in the whole of Germany,' and that all his practice has taught him 'the solidness and closeness of a well-constructed zinc roof.'

"Oak boarding will spoil the zinc, and the fir should be dry; the boards laid with an aperture of about half an inch between each; if they are damp, as much oxidation will take place on the underside of the zinc as on the top of it.

"A good way of laying flats in some situations is without rolls, but with sunk gutters between the sheets, with, in fact, inverted rolls, which form gutters; for London, however, I would recommend the ordinary way, as the small gutters are liable to be filled

with blacks and soot if neglected. In forming laps care must be taken to prevent the water from ascending, by capillary attraction; there must either be space enough to prevent the drops thus rising, or the end of one sheet must touch altogether, and that of the other be kept well away; and this is found the best mode, and the least open to careless treatment by workmen.

"The thicker the zinc, the less its expansion and contraction. And I find as follows, in a report made to the Academy of Sciences, by the director of the Conservatoire des Arts et Métiers, a government institution existing in the Rue St. Martin, to inquire into scientific inventions, civil engineering, and all constructive science:—

"'It appears from actual experiment, that the oxidation proceeds for about four years, gradually diminishing after the first three months, and that it then hardens into a protecting coat ('émail') of a dark grey color, preserving the metal beneath from any further deterioration.' And it concludes by saying, 'that it becomes evident that as a sheet of zinc exposed to the atmosphere for a series of years loses little or nothing of its weight or thickness, and as its surface remains hard and polished, like enamel, it may be fairly deduced that the following years are not likely to occasion any alteration, and therefore that zinc will be placed in the same condition as bronze, which is protected by its 'patine' for ages.'"

Amongst new works in Paris, Mr. Edmeston mentions—

"The new markets, constructed of iron, under the direction of M. Baltard, architect, in 1856. These great roofs are covered wholly with zinc, No. 14 gauge, the gutters being No. 16, the whole in perfect condition, except in one place, where some undulation has occurred in consequence of the workmen having confined the metal by solder very needlessly, because a little extra labor was necessary to lay the zinc properly: the down pipes are of zinc No. 14.

"Also the entire roofs of the magnificent houses forming the Boulevard de Sebastopol, the new mansions in the Champs Elysées, the new part of the Louvre, in which the flats of the zinc and the curbs only of slate; the roof of the Hôtel de Villa; the roof of the Church of St. Clothilde; and, in fact, nearly every roof formed in Paris within the last fifteen years."

He mentions,—

"That while cement does no injury to the zinc, the lime of Paris destroys it, and that when cisterns or other zinc constructions are confined with brick-work, in mortar, the custom is to fill in round them with earth so as to protect the zinc from the lime."

A report of a committee, appointed by the Central Society of Architects in Paris, recommends,—

"That zinc, which was at first rejected, but is now so generally used, should be applied with great care, as certain precautions, very simple, but never to be overlooked, are indispensable: thus contact with plaster, which contains a destructive salt, is to be avoided; also contact with iron, which is very injurious, and liable to cause a rapid oxidization: eaves gutters should always be supported by galvanized brackets, and no gutter or sheet zinc should be laid on oak boards."

Mr. Edmeston deduces from these facts and independent inquiries, that it is impossible longer to contend—

"That zinc is other than a valuable and excellent material for building purposes, too important to be overlooked, and worthy of a more extended use and of a better appreciation than it has yet received with us."

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*Experiments on the Strength of Cast Iron Girders.** By J. G. Lynde, M. I. C. E., F. G. S.

The following paper was read at the Manchester Literary and Philosophical Society, Nov. 1, 1859.

The beams experimented on were eighty-nine in number, and were cast by Mr. Mabon, at the Ardwick Iron Works, Manchester, from iron of the following descriptions:—

* From the Mechanics' Magazine, Dec., 1859.

One charge of the cupola consisted of

12	cwt.	Goldendale, Staffordshire.
12	"	Lane End.
12	"	Ormesby, Yorkshire.
12	"	Blair, Scotch.
12	"	Calder, "
		All No. 3 hot blast iron.
12	"	Scrap.

The beams were cast on their sides, and were a very good sample of workmanship.

The section of each beam was of the form recommended by Professor Hodgkinson, and upon which his formulæ were based; the total depth of the beam in the centre was 24¼ inches, and at the ends 20 inches; the bottom flanch was 15 inches wide, and 2¼ inches thick; the vertical part of the beam was 1½ inch thick; and the top flanch was 4⅛ ins. wide, and 1½ ins. thick; the total length of the beam was 34 feet 6 inches, and the distance between the supports was 30 feet 9 inches; the weight of the beam was 3 tons 8 cwt. 1 qr.

One of the beams was tested up to the breaking weight with the following results:—

With a load in the centre of—

Tons.	Cwt.		Inch.
31	8	the deflection was	·87.
42	16	"	2·00.
46	12	"	2·25.
50	8	"	2·56.
54	4	"	2·70.
58	0	the beam broke,	

the ends springing back from each other 2 feet 3 inches, the fracture indicating a good sound casting.

There was no permanent set observable in any of the experiments, until the breaking weight was applied, the beam being allowed to recover itself on the removal of the load in each case.

Each of the remaining beams was tested with a load of 20 tons in the centre, the deflection varying from ⅝ to ⅞ of an inch.

The calculations for the strength were based on the following formulæ, given by Professor Hodgkinson in his "Experimental Researches on the Strength and Properties of Cast Iron:"—

First formula, art. 146:

Let w = the breaking weight in tons placed on the centre of the beam,

a = the area of the bottom flanch in inches,

d = the total depth of the beam in inches,

l = the length between the supports in feet,

$$\text{then } w = \frac{2{\cdot}166\, a\, d}{l}$$

In this case

$a = 36{\cdot}$

$d = 24{\cdot}25,$

$l = 30{\cdot}75,$

which gives 60·09 tons as the breaking weight of the beam.

The second formula, art. 147, takes into account the thickness of the vertical part of the beam, and is as follows:—

Let w = the breaking weight in tons placed on the centre of the beam,
l = the length between the supports in feet,
b = the breadth of the bottom flanch in inches,
b' = the thickness of the vertical part in inches,
d = the whole depth in inches,
d' = the depth from the top of the beam to the upper side of the bottom flanch in inches,

$$\text{then } w = \frac{2}{3\,d\,l}\left(bd^3 - (b - b')\,d'^3\right).$$

In this case
$l = 30{\cdot}75,$
$b = 15{\cdot}$
$b' = 1{\cdot}5,$
$d = 24{\cdot}25,$
$d' = 22{\cdot}03,$

which gives 62·19 tons as the breaking weight of the beam.

The actual breaking weight being 58 tons, it would appear that the constant co-efficient assumed is in each instance too high for the quality of iron of which these beams were cast. This result appears to have been anticipated by Professor Hodgkinson in the case of large beams; and in one of his experiments, art. 147, on a beam cast for Messrs. Marshall and Co., of Leeds, he gives ·625 as the co-efficient, which agrees with the result of this experiment.

Applying this co-efficient to Professor Hodgkinson's formulæ, they will be as follows:—

$$\text{First formula, } w = \frac{2{\cdot}05\,ad}{l}$$

$$\text{Second formula, } w = \frac{{\cdot}625}{d\,l}\left(d\,b^3 - (b - b')\,d'^3\right).$$

The first of these would give 58·2 tons, and the second 58·31 tons, as the breaking weight; either of which calculations would be sufficiently correct for any practical purpose.

Claim to the Invention of Hunt's Steam Boiler.

To the Editor of the Journal of the Franklin Institute.

Sir:—In the *London Engineer* of Nov. 30, and in a recent number of the *Practical Mechanic's Magazine*, will be seen a description and cut of a boiler patented Feb. 14, 1859, by Mr. Thomas Hunt, of Crewe, England, which is substantially the same as that patented and put in use by Capt. R. F. Loper, of this city. The *Patent Office Report* for 1849, and the *Journal of the Franklin Institute* of same year, Vol. xviii, Third Series, contain the specification and claim, which are:

"The object of my invention is, so to construct a boiler as to cause the products of combustion from the furnace or furnaces to divide into two parts, and again commingle

alternately through a series of labyrinth flues, against the sides of which they are caused to impinge many times in the course of their passage through the boiler."

A modification of this plan is had by placing a series of vertical tubes in the flues.

Claim.—"What I claim as new, is constructing the boiler in the manner described, by the employment of a series of central and side water tables, forming a flue in which the gases are alternately divided and commingled, in the manner and for the purpose set forth."

Shortly after the issuing of the patent, two boilers were built upon his plan, for Capt. Loper, at the works of Messrs. Reaney, Neafie & Co., from drawings made by the writer, and placed one on board the steam barge *Hector*, and the other on the tug *Charles H. Haswell*, where they are still in use from present accounts, and giving satisfaction. The latter boat has two cylinders of 12 ins. bore, 12 ins. stroke; carrying steam for half-stroke, and making about 100 revolutions per minute. The boiler of this boat was the first made. The dimensions are not remembered, but it is quite small; nevertheless, the flues are of sufficient size to admit of access for cleaning and repairs.

The *Hector* has one cylinder 18 ins. diameter, 24 ins. stroke, carrying steam for half-stroke, and making 75 to 80 revolutions per minute. Her boiler is 12 ft. long, 6 ft. 6 ins. wide and high; furnace 3 ft. 6 ins. long, by 5 ft. 6 ins. wide in the clear. The balance of the boiler contains the flues and water legs, thus: The water leg forming the back of the furnace, is 6 ins. in clear, and has an opening in the middle, rising from grate bars to crown of furnace, of 18 ins.; then comes the flue about 13 ins. in clear; then a water leg of 5½ ins. in clear, with a flue on each side between it and the sides of the boiler, of 10 ins. wide, and extending from water bottom to crown; then a flue of 13 ins. again succeeded by water legs of 5 ins. in clear, extending from the sides towards each other, with a passage of 15 ins. between them, and so on; the water legs diminishing by half inches as they approached the back end of the boiler; but the flues are made of the same size to permit of access.

In addition, a row of return flues about 5½ ins. in diameter, was placed above the water legs in order to determine the efficiency of the boiler with an increased amount of surface, compared with that in the *C. H. Haswell*, in which the temperature of the escaping gases was considered to be too high; the small size of the boiler compelling a sacrifice of heat-absorbing surface, in order to get flues of such a size as would afford a passage through them for examination and cleaning. As expected, a gain resulted from the addition of flues. The uptake was not in danger of being overheated by hard firing, whilst it proved that the boiler could be shortened, thus saving valuable freighting-space. The Patentee did not strongly advocate the introduction of the original form, his preferences being for that with the vertical tubes in the flues; hence, it was not placed upon any other boats than those named, whilst the modified type was put upon several steam barges plying between Philadelphia and New York, where it proved to be both economical and efficient.

This claim is not intended to detract from the merit of Mr. Hunt, as an inventor, as he no doubt is not aware of his having been anticipated; but simply to show that the priority of design and introduction to active use, belong to Capt. Loper. J.

For the Journal of the Franklin Institute.

Proposed remedial alterations of, and additions to, the present Law regulating the grant of Letters Patent for Designs.

By H. Howson.

By the third section of an Act approved August 29th, 1842, "in addition to an Act to promote the Progress of Science and the Useful Arts, and to repeal all acts and parts of acts heretofore made for that purpose," a new class of objects, for which no protection had been previously afforded by legislative enactments, was made the subject of Letters Patent, the duration of which is for seven years; the fees being fifteen dollars.

These patents are for new and original designs applied to any manufacture, whether of metal or other material, the act taking no cognizance of any peculiar advantages or utility which the object may possess, or of any process or art by which the form or ornamentation of the object is produced.

The ornamental articles of manufacture which would form appropriate subjects for this class of patents, are so numerous that it would be a difficult matter to classify them, and yet how few manufacturers of such articles avail themselves of a law which was evidently enacted for their especial benefit! How few instances of new ornamental fabrics, new styles of jewelry, or other objects, the merits of which depend, for the most part, on their ornamentation and pattern, are to be found in the list of patents for designs!

It cannot be supposed that the manufacturers of such articles have no desire to maintain a brief monopoly of their productions and a protection against copies and imitations of their wares by rival manufacturers.

How is it, then, that they so seldom avail themselves of the protection which the Act of 1842 is presumed to afford?

The cause of this cannot be attributed to any indifference or neglect on the part of the manufacturers, but to some radical defect in the law.

A lengthened experience as a Patent attorney has convinced the writer that such is the case; and that the defects are a source of general complaint, and that the law is generally unpopular.

The Act has been declared to be ambiguous by more than one good legal authority, and its ambiguity has been frequently admitted by the authorities of the Patent Office.

The defects of the Act regulating the grant of Letters Patent for designs may be classed under two general heads.

First, the duration of the patent and the amount of fees are the same for every ornamental article of manufacture, and this, it is believed, is the main imperfection of the law.

Secondly. The law affords a very doubtful protection against infringers on a patented design.

It is proposed to devote the present paper to the discussion of the defects arising from the uniformity in the charges for and the duration of the time of patents for designs, and to suggestions as to the most appropriate remedies, leaving the inquiries as to the insecurity of this class of patents for a future communication.

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It is contended that for some ornamental articles, a patent of seven years' duration is too short, and for other articles too long.

In order to demonstrate this clearly, it will be necessary to discuss the subject in reference to two objects of a very different nature.

A design for an ornamental stove and a fabric of a new and ornamental pattern, will be appropriate selections for this purpose.

Under the present law, the patent will endure for seven years and the fee will be fifteen dollars in both cases.

Now, in getting up a new design for a stove, the manufacturer must, in the first place, be possessed of a well cultivated taste, a readiness for producing figures and ornaments of pleasing effect.

In the second place, he must be in possessoin of the requisite capital to meet the expenses.

In preparing a new design for a stove, it is necessary to make three or four sizes; the patterns for these cost one, two, or even three thousand dollars, according to the nature and extent of the ornamentation.

Is there any just reason why a new and original ornamental manufacture which requires such an outlay as this, which demands no small amount of taste and artistic skill, should be protected by a patent of only seven years' duration, while trifling mechanical devices, many of them of doubtful merit, requiring but little outlay, and the exercise of very limited inventive faculties, are protected by a patent of fourteen years' duration?

It may be argued that in one case the object relates to ornaments of no intrinsic value; whereas the object in the other case is for the accomplishment of some useful end, and that one object is, therefore, a more appropriate subject for legislative protection than the other.

This would be a very contracted view of the matter.

It is true that the production of an original ornamental design and the invention of a new machine, art, or composition of matter, require different mental capacities, but both are of equal value to a civilized community.

Ingenuity and art go hand in hand together; both have an equal demand on the fostering care of the government; as much, and perhaps more, time and labor are expended in the production of ornamental articles of manufacture which are fit subjects for patents for designs, as in the construction of appliances which can be protected by the ordinary class of patents. Why then should the laws make an invidious distinction between the inventor and the artist? Why should the laws say to the designer of jewelry, "You can have a seven years' patent for your design for a bracelet," and to the inventor, "You can

have a fourteen years' patent for your device which forms the fastening for the same bracelet."

It is an anomalous law which restricts the duration of a patent for a design to seven years, because it is a superfluous ornament, and protects the fastening, on the ground that it is a mechanical device for securing the same superfluous ornament. There can be no just reason why the designer should not be allowed to protect his production for the same length of time as the inventor.

The framers of the Act of 1842 had, doubtless, no intention of legislating to the injury of the artist; they may have been actuated by every desire to encourage art in deciding upon the reduced term for the duration of this class of patents and the reduced fees, thinking that it would meet the wishes and requirements of the designers themselves.

They appear, however, to have lost sight of the fact that the law must have an unequal bearing on the producers of different ornamental articles.

To return to the manufacture of ornamental stoves. It has been already remarked that the preparation of the patterns is a most costly matter; so great is the original outlay that every stove manufacturer would be glad to secure his design for double the length of time at present allowed, by the payment of additional fees.

It is well known that small manufacturers, men with neither taste, enterprise, nor capital, are in the habit of waiting for the expiration of a patent of a popular and elaborately carved stove, and after this expiration, of purchasing a stove, using the plates for patterns, and furnishing them to the public to the injury of the original producers.

If a stove will retain its popularity for twelve or fourteen years, who should reap the benefit of that popularity? Surely not the piratical foundryman, who not only makes a fac-simile of the stove, but actually uses the plates for patterns; but the original designer or producer, the man who can command the necessary artistic talent, the capital to turn that talent to account, and the business tact and enterprise which enable him to furnish the public with a highly ornamental article of utility, at a comparatively small cost.

An extended intercourse with stove manufacturers enables the writer to assert that quite as many patents would be obtained for designs for stoves at a charge of $30 government fee, as are now procured at a cost of $15; provided the duration of the patent could be increased in proportion.

If the duration of a patent for a design, however, be fixed at fourteen years and the fees at $30, the law, while it worked to the advantage of stove manufacturers, would bear injuriously and unjustly on manufacturers of other ornamental articles.

The producer of the ornamental fabric would deem it a great hardship if he was compelled to pay $30 for the protection of a design which would, most probably, be out of fashion in two or three years.

For a class of ornamental articles, the sale of which depends on the caprices of fashion, the duration of the patent as at present fixed by law (seven years) is too long, and the fees ($15) too large.

It is, for the most part, the amount of fees demanded which has hitherto prevented manufacturers of an extensive class of ornamental goods from availing themselves of the protection which the present law affords.

Could the manufacturer of the ornamental fabrics obtain a patent for three years by paying a government fee of $5, $6, or $7, there can be no doubt that numbers would avail themselves of an opportunity which they had hitherto neglected on the ground of economy.

It appears to the writer, that a very simple alteration of that part of the law which regulates the duration of time and the amount of fees for patents for designs would meet the exigencies of all manufacturers of ornamental articles.

The proposed alteration is, to establish three classes of patents, as follows:

First class, duration	14 years,	fee, $30·00
Second " "	7 "	" 15·00
Third " "	3½ "	" 8·00

Then will arise the question—"who shall have the power of classifying the different ornamental articles which form the application of patents for designs?"

Not the authorities of the Patent Office, for this would be too arbitrary a measure, and one which would give rise to tedious and expensive correspondence between the applicants and the Office, and would be a certain source of much dissatisfaction.

Let the producers or applicants themselves select the class under which they desire the patent to be granted.

This is a power which may be safely entrusted into their hands.

The stove manufacturer will deem it to his interest to select the first class; the designer of a bust of some popular character, thinking that his production will retain its popularity for seven years, might select the second class.

The weaver, and wall-paper manufacturer, owing to the sudden changes in the fashion of their productions, would doubtless select a patent of the third class.

After the patent has been granted for the time selected by the applicant, he should be allowed no extension of this time; he should have no right to transfer his patent of the third class to that of the second or first class, by the payment of additional fees; should such a course be allowed, it would certainly give rise to much extra labor in the Patent Office, much confusion and constant litigation.

If an applicant has selected for his production a three years' patent, and subsequently discovers that the design patented will retain its popularity for a longer period than he expected, no fault could be found with the law, as it afforded him an opportunity of selecting a longer term; the blame rests with himself, and his own want of foresight.

The law, too, should compel the patentee to mark the article patented, not only with the date of the patent, but with the class under

which it has been issued, so that the public may be aware of its true nature and extent.

Should such modifications be established, it would be but an act of justice to introduce a provision by which the holders of unexpired patents for designs granted under the old law, might, by the payment of the extra fees, have their patents extended to fourteen years from the date of the original grant.

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Whenever any sweeping modification in the law regulating the grant of Letters Patent is contemplated, there are three points to be considered in connexion with the proposed alterations.

First. How will it affect the public?

Secondly. What effect will it have on the manufacturer? and

Thirdly. Will it tend to increase or diminish the revenues of the Patent Office?

What effect will the alterations suggested above, have as regards the interests of the general public?

A manufacturer of ornamental articles, whose productions can be protected at a trifling cost, will have some inducement for calling into play superior skill, and a higher class of art, knowing that the monopoly will prove an ample re-payment for the outlay and exertion; the rival manufacturer will endeavor to outstrip his neighbor in producing articles of a superior and more attractive design.

Thus would the demand for labor be increased, the cultivation of the higher branches of art be stimulated, and the restless demands of the public for constant changes in all ornamental articles be satisfied.

It will be needless to remark, that the manufacturers and producers must be benefited by the above alterations; the benefit being especially felt by the manufacturers of stoves and other metal ornaments;—smaller manufacturers of this class of articles will, no doubt, continue to use as patterns the castings from the original design, even after the expiration of a patent of fourteen years.

But the alteration will, at least, allow the original designer to effect sales sufficient to repay him for the outlay before the piratical foundryman can deprive him of his monopoly.

What effect will the proposed alterations have on the revenues of the Patent Office?

As many, or perhaps, more patents for designs for stoves would be granted under fees of $30, as have hitherto been issued under fees of $15, so that the revenue arising from this class of ornamental articles would be at least doubled, without the demand of any extra labor on the part of the Patent Office clerks.

Then the alterations would open a channel for a further revenue arising from patents of the second and third class.

It is impossible to estimate the probable number of applications of the third class of patents, but it is very certain that as soon as the producers became aware of the facilities which the law afforded for protecting their productions at a trifling cost, the number of applications would be very large, and the revenue proportionately increased.

It is true that an extra number of clerks might be necessary to attend to this influx of patents of the third class, but the salaries of these additional clerks would be but a fraction of the revenue derived from the additional fees resulting from the alterations suggested above.

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*On Phosphorescence, Fluorescence, &c.** By Prof. FARADAY.

The agent understood by the word "light," presents phenomena so varied in kind, and is excited to sensible action by such different causes, acting apparently by methods differing greatly in their physical nature, that it excites the hopes of the philosopher much in relation to the connexion which exists between all the physical forces, and the expectation that that connexion may be greatly developed by its means. This consideration, with the great advance in the experimental part of the subject which has recently been made by E. Becquerel, were the determining causes of the production of this subject before the Members of the Royal Institution on the present occasion. The well-known effect of light in radiating from a centre, and rendering bodies visible which are not so of themselves, as long as the emission of rays was continual—the general nature of the undulatory view, and the fact that the mathematical theory of these assumed undulations was the same with that of the undulation of sound, and of any undulations occurring in elastic bodies, were referred to as a starting position.—Limited to this effect of light it was observed that the illuminated body was luminous only whilst receiving the rays or undulations. But superadded occasionally to this effect is one known as *phosphorescence*, which is especially evident when the sun is employed as the source of light. Thus, if a calcined oyster-shell, a piece of white paper, or even the hand, be exposed to the sun's rays, and then instantly placed before the eyes in a perfectly dark room, they are seen to be visible *after* the light has ceased to fall on them. There is a further philosophical difference, which may be thus stated; if a piece of white oyster-shell be placed in the spectrum rays issuing from a prism, the parts will, as to illumination, appear red, or green, or blue, as they come under the red, green, or blue rays; whereas if the phosphorescent effect be observed, *i. e.* that effect remaining after the illuminating rays are gone, the light will either be white, or of a tint not depending upon the color of the ray producing it, but upon the nature of the substance itself, and the same for all the rays. The ray which comes to the eye in an ordinary case of visibility, may be considered as that which, emanating from the luminous body, has impinged upon the substance seen, and has been deflected into a new course, namely, towards the eye; it may be considered as the same ray, both before and after it has met with the visible body. But the light of phosphorescence cannot be so considered, inasmuch as *time* is introduced; for the body is visible for a time sensibly after it has been illuminated, which time in some cases rises up to minutes, and perhaps hours. This condition connects these phosphorescent bodies with those which phosphoresce by heat, as apatite and fluor-spar; for when these are made to glow intensely by a heat

*From the Lond. Athenæum, July, 1859.

far below redness, it is evident that they have acquired a state which has enabled them for a time to become original sources of light, just as the other phosphorescent bodies have by exposure to light acquired a like state. And then again there is this further fact, that as the fluor-spar, which has been heated, does not phosphoresce a second time when re-heated, still it may be restored to its first state by passing the repeated discharge of the electric spark over it, as Pearsall has shown. Then follows on (in the addition of effect to effect) the phenomena of *fluorescence*, and the fine contributions to our knowledge of this part of light by Stokes. If a fluorescent body, as uranium glass, or a solution of sulphate of quinine, or decoction of horse-chestnut bark, are exposed to diffuse day-light, they are illuminated, not merely abundantly but peculiarly, for they appear to have a glow of their own; and this glow does not extend to all parts of the bodies, but is limited to the parts where the rays first enter the substances. Some feeble flames, as that of hydrogen, can produce this glow to a considerable degree. If a deep blue glass be held between the body and the rays of the sun, or of the electric lamp, it seems even to increase the effect; not that it does so in reality, but that it stops very many of the luminous rays, yet let the rays producing the effect pass through. By using the solar or electric spectrum, we learn that the most effectual rays are in most cases not the luminous ones, but are in the dark part of the spectrum; and so the fluorescence appears to be a luminous condition of the substance, produced by dark rays which are stopped or consumed in the act of rendering the fluorescent body luminous: so they produce this effect only at the first or entry surface, the passing ray, though the light goes onward, being unable to produce the effect again; and this effect exists only whilst the competent ray is falling on to the body, for it disappears the instant the fluorescent substance is taken out of the light, or the light shut off from it. When E. Becquerel attacked this subject he enlarged it in every direction. First of all, he prepared most powerful phosphori; these being chiefly sulphurets of the alkaline earths, strontia, baryta, lime. By treatment and selection he obtained them so that they would emit a special color: thus, seven different tubes might contain preparations which, exposed to the sun, or diffused day-light, or the electric light, should yield the seven rays of the spectrum. The light emitted generally possessed a lower degree of refrangibility than the ray causing the phosphorescence; but in some instances he was able to raise the refrangible character of the ray emitted to that of the exciting ray. By taking a given preparation, and raising it to different temperatures, he caused it to give out different colored rays by the single action of one common ray; this variation in power returning to a common degree as the temperatures of the phosphori became the same in all. He showed that *time* was occupied in the elevation of the phosphorescent state by the ray; and also that time was concerned in various degrees during the emission of the phosphorescent ray: that this time, which in many cases was long, might be affected, being shortened by the action of heat, and then the brilliancy of the phosphorescence for the shortened time was

increased. He showed the special relation of the different phosphori to the different rays of the spectrum, pointing out where the maximum effect occurred; also that there were the equivalents of dark bands, *i.e.* bands in the spectrum, where little or no phosphorescence was produced. These phosphori were many of them highly fluorescent. Thus, if one of them was exposed to the strong voltaic light, and then placed in the dark, it was seen to be brilliantly luminous, gradually sinking in brightness, and ultimately fading away altogether: but if it were held in the rays beyond the violet end of the spectrum (the more luminous rays being shut off) it was again seen to be beautifully luminous, but that state disappeared the instant it was removed from the ray. Now this is fluorescence, and the same body seemed to be both phosphorescent and fluorescent. Considering this matter, and all the circumstances regarding time, Becquerel was led to believe that these two luminous conditions differed essentially only in the *time* during which the state excited by the exposure to light continued; that a body being really phosphorescent, but whose state fell, instantly, was fluorescent, giving out its light while the exciting ray continued to fall on it, and during that time only; and that a phosphorescent was only a more sluggish body, which continued to shine after the exciting ray was withdrawn. To investigate this point he invented the *phosphoroscope;* an apparatus which may vary in its particular construction, but in which discs or other surfaces illuminated by the sun or an electric lamp might, by revolution, be rapidly placed before the eye in a dark chamber and so be regarded in the shortest possible space of time after the illumination. By such an apparatus Becquerel showed that all the fluorescent bodies were really phosphorescent; but that the emission of light endured only for a very short time. An extensive series of experimental illustrations upon the foregoing points was made with some fine specimens of phosphori, for which the speaker was indebted to M. Becquerel himself. The phosphoroscope employed consisted of a cylinder of wood, one inch in diameter and seven inches long, placed in the angle of a black box with the electric lamp inside, so that three-fourths of the cylinder were external, and in the dark chamber where the audience sat, and one-fourth was within the box, and in the full power of the voltaic light. By proper mechanical arrangements this cylinder could be revolved, and the part which was at one instant within, rapidly brought to the outside, and observed by the audience. As the cylinder could be made to revolve 300 times in a second, and as the twentieth part of a revolution was enough to bring a sufficient portion of the cylinder to the outside, it is evident that a phosphorescent effect which would last only the 1-3000th or even the 1-6000th of a second might be apparent. All escape of light between the moving cylinder and the box was prevented by the use of properly attached black velvet. The cylinder was first supplied with a surface of Becquerel's phosphori. The effect here was, that when by rotation the part illuminated was brought outside the box it was found phosphorescent. If the cylinder continued to rotate it appeared equally luminous all over, and when the rotation ceased, or the

lamp was extinguished, the light gradually sank as the phosphorescence fell. Then a cylinder having a surface of quinine or æsculin was put into the apparatus. Whilst the cylinder was still it was dark outside; but when revolving with moderate velocity it became luminous outside, ceasing to be so the moment the revolution stopped. Here the fluorescence was evidently shown to occupy time: indeed, the full time of a revolution: and taking advantage of that, the self-shining of the body was separated from its illumination within, and the fluorescence made to assume the character of phosphorescence. Another cylinder was covered with crystals of nitrate of uranium, a hot saturated solution having been applied over it with a fine brush. The result was beautiful. A moderate degree of revolution brought no light out of the box; but with increased motion it began to appear at the edge. As the rapidity became greater, the light spread over the cylinder, but it could not be carried over the whole of its surface. It issued as a band of light where the moving cylinder left the edge of the box, diminishing in intensity as it went on, and looking like a bright flame, wrapping round half the cylinder. When the direction of revolution was reversed, this flame issued from the other side; and when the motion of the cylinder was stopped, all the phenomena of fluorescence or phosphorescence disappeared at once. The wonderfully rapid manner in which the nitrate of uranium received the action of the light within the box, and threw off its phosphorescence outside, was beautifully shown. The electric light, even when the discharge is in rarified media, or as a feeble brush, emits a great abundance of those rays which produce the phenomena of fluorescence; but then if these rays have to pass through common glass they are cut off, being absorbed and destroyed even when they are not expended in producing fluorescence or phosphorescence. Arrangements can however be made in which the advantageous circumstances can be turned to good account with such bodies as Becquerel's phosphori or uranium glass. If these be enclosed within glass tubes, having platinum wires at the extremities, and which are also exhausted of air and hermetically sealed, then the discharge of a Ruhmkorff coil can be continually sent over the phosphori, and the effects both fluorescent and phosphorescent be beautifully shown. The first or immediate light of the body is often of one color, whilst on the cessation of the discharge the second or deferred light is of another; and many variations of the effects can be produced. In connexion with rarefied media it may be remarked, that some of the tubes by Geissler and others have been observed to have their rarefied atmospheres phosphorescent, glowing with light for a moment or two after the discharge through them was suspended. Since then Becquerel has observed that oxygen is rendered phosphorescent, *i.e.* that it presents a persistent effect of light, when electric discharges are passed through it. I have several times had occasion to observe that a flash of lightning, when seen as a linear discharge, left the luminous trace of its form on the clouds, enduring for a sensible time after the lightning was gone. I strictly verified this fact in June, 1857, recording it in the *Philosophical Magazine*,

and referred it to the phosphorescence of the cloud. I have no doubt that that is the true explanation. Other phenomena, having relation to fluorescence and phosphorescence, as the difference in the light of oxygen and hydrogen exploded in glass globes, or in the air, were referred to, with the expression of strong hopes that Becquerel's additions to that branch of science would greatly explain and extend them.

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*On the Progress of Steam Navigation at Hull.**

By JAMES OLDHAM, M. Inst. C. E.

For generations past, Hull has been noted for its Greenland and Davis Straits fishery, and for many years this has constituted the chief feature of the port. Within the last two or three years steam has been put into successful requisition to aid the dauntless and hardy mariner in the pursuit of this hazardous calling, and now we have several screw steam ships employed; and although some of them are fitted with comparatively small power, they have proved to be possessed of great advantage in the service, and in some instances satisfactorily to the owners. We have had two descriptions of steam vessels employed in the fishery; the first, the old wooden sailing ships, which had been engaged in the service for some years, but which were afterwards fitted with screw machinery and auxiliary steam power. The second, iron-built ordinary screw steam vessels; but which proved, I believe, almost a total failure: the material of which they were built and the want of strength for such a purpose proving them altogether unfit to contend with the severity of the climate and rough encounters with the bergs and fields of ice, some becoming total wrecks, while others returned bruised and rent, and were with difficulty kept from sinking. A question here arises, how far iron ships are calculated to bear the severe frosts of high latitudes, and whether wooden-built vessels, with all their defects, are not the best adapted for encountering such a climate? The screw steam ship which was first sent from Hull, or any other place, to the fishery as an experiment, was the *Diana*, timber-built, 355 tons and 40 horse-power, high pressure, the property of Messrs. Brown, Atkinson & Co., of Hull. This vessel had been some time engaged in the fishery as a sailing ship; but her spirited owners, thinking an important advantage could be gained, determined upon the adoption of steam power, and at once had the *Diana* fitted up for the spring of 1857 by Messrs. C. and M. Earle, who put in the engines, and made the screw to lift out in case of need. The experiment fully answering their expectations, Messrs. Brown, Atkinson & Co. bought the *Chase*, a fine American built ship of immense strength, and of 558 tons. She was fitted by Messrs. Martin, Samuelson & Co. with condensing engines of 80 horse-power, and dispatched to the fishery in the early part of 1858, and with good results. By the application of steam, ships in this service can now make a voyage first to Greenland, and afterwards to the Davis Straits. In the commencement of this year several ordinary iron screw steamers were dispatched to Greenland,

* From the London Civ. Eng. and Arch. Jour., Dec., 1859.

viz: the *Corkscrew*, *Gertrude*, *Emmeline*, and *Labaun;* the latter only of this class, which is the property of Messrs. Bailey & Leetham, had any success; but in consequence of her great strength and peculiar form, succeeded in a tolerable way; the others were much damaged, and, as I have already remarked, returned in a bad condition. The *Labaun* is 584 tons burthen and 40 horse-power.

The next point of interest connected with the steam ships of the port of Hull refers to alterations made in some of the vessels. The *Emerald Isle*, a paddle timber-built ship of 1835, the property of Messrs. Gee & Co., originally $135\frac{8}{10}$ long, lengthened 35 feet, with a gain of 14 inches draft of water, and an increased capacity for 100 tons dead weight. The *Sultana*, iron screw steam ship of 1855, the property of the same house, originally 150 feet long, lengthened 30 feet, with a gain of 10 inches draft of water, and an increased capacity of about 100 tons. It is interesting to observe that in both cases we have no diminution of speed through the water, and that both vessels are improved as sea boats. Daily experience teaches the advantage gained, in almost every point of view, by ships of great comparative length. The iron steam-ship *Lion*, of Hull, formerly a paddle-boat 249 feet long, but now converted into a screw steamer by her owners, Messrs. Brownlow, Lumsden & Co., under the direction of Mr. Anderson, their engineer, exhibits the great advantage gained by the alteration. Her register tonnage is 690, and the total tonnage 1014. She was formerly fitted with steeple engines of 350 horse-power, and had four boilers, two before and two abaft the engines; but these were substituted for direct action engines of 150 horse-power, and two of her old boilers replaced, and by this alteration a clear length of hold in midships of 23 feet is gained. She required before the conversion 650 tons of coal for a St. Petersburg voyage, and consumed 30 to 40 cwt. per hour; but now 350 tons for the voyage, and a consumption of 20 cwt. per hour. By the change of machinery about 130 tons of dead weight is removed from the ship, and she is now able to carry 400 tons more cargo. Her speed is also improved considerably; before the alteration, when drawing 14 feet, the rate was six knots and a half, but since the change, when drawing even more water, they can steam eight knots. Thus, throughout, a saving in almost all departments of the ship, and other advantages, have been effected by this important change. During the last two years many fine steam ships have been built in Hull, and others are in process of building for English and foreign service by Messrs. Brownlow, Lumsden & Co., Messrs. C. and W. Earle, and Messrs. Martin, Samuelson & Co. The last-named firm are making rapid progress in the building of two large paddle steam ships for the Atlantic Royal Mail Steam Navigation Company, of the following dimensions, power, &c.—

	Feet.
Length between the perpendiculars,	360
Beam moulded,	40
Depth,	30
Tonnage, builder's measure,	2860
Nominal horse power,	800

These ships are to have three decks, and to be fitted fore and aft for passengers. Speed through the water, twenty miles per hour. They will be of immense strength, and their build and form such as to insure their becoming fine sea boats.

Since the meeting of the British Association at Dublin, considerable advance has been made in London and other ports in the application of superheated steam, and, I believe, with great success and satisfaction in the results; Hull, however, before taking a decided step in this important discovery, is anxious to see and adopt the best mode of the application of the principle, being assured that in every onward movement it is better "to make no more than good speed." Some attention has been paid to the consumption of smoke in the furnaces of our steam vessels, and with a considerable amount of success. I may here mention the mode of Mr. Ralph Peacock, of New Holland, Hull, for which he has taken out a patent. It consists of a double furnace-door, the chamber or space between the inner and outer surfaces being five to six inches in width. The inner plate is perforated very full of small holes, and in the outer plate a revolving ventilator is inserted, which is on the principle of that invented by Dr. Hale to supply close places with fresh air. The apparatus is in use on board the *Helen Macgregor*, one of Messrs. Gee & Co.'s large sea-going steam ships, and has given very general satisfaction, for by the report of the chief engineer, Mr. McAndrew, a saving of fuel is effected, and the steam better sustained. Another great advantage, as reported by the master, Captain Knowles, derived from this invention is, that on running before the wind they are never now annoyed and endangered by a dense cloud of smoke in the direction of the ship's course, which, particularly at night time, creates so much risk of collision. This apparatus is also in use on board several other steamers, viz., the *Yarborough* and *Grimshaw*, belonging to the Anglo-French Company, the *Albert*, of Hull, and also a number of river steamboats. I have great pleasure in noticing also an improvement introduced on board the *Queen of Scotland*, another ship belonging to Messrs. Gee & Co., for the same object, by the chief engineer, Mr. Smith, and having furnaces of ample capacity, answers the purpose in a most satisfactory manner. Mr. Smith's mode consists simply in keeping a few inches off the front ends of the bars quite clear and clean from side to side of each furnace, thus admitting at the right place a sufficient amount of air. The report of the master, Captain Foster, is very satisfactory. I have witnessed also the effect of this mode on the furnaces of stationary boilers with perfect results.

I have now to refer to the application of Silver's Marine Governor, as applied by John Hamilton, of Glasgow. Several of these ingenious and effective instruments are now in use on board steam ships in the port of Hull, giving the highest satisfaction. They are so sensitive in their action, that the slightest pitching motion is at once indicated, and the steam admitted or excluded as the case may be. By the use of this governor the full power of the engines is in immediate requisition, producing the effect of saving of time, saving of fuel, and pre-

venting of accidents by what is termed racing and otherwise. The ordinary mode, in the absence of the governor, is for the engineer in stormy weather and heavy seas continually to stand at the throttle-valves, or, to save himself this trouble, to throttle the engines; and thereby when the full power of the engines is most required, it is frequently reduced to one-half or less, and consequently there is occasioned a loss of time on the voyage, and the risk of falling on to a lee shore.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.,

Professor of Civil Engineering in the Philadelphia High School.

FEBRUARY.—The month of February, 1860, was remarkable for its many extreme changes, both in the temperature and pressure of the atmosphere. During the night between the 1st and 2d days of the month, the register thermometer indicated a temperature as low as 1 degree; while, at 2 P. M. of the 23d, it reached 70 degrees. At no other period during the last nine years did the temperature rise so high in the month of February; and only once during the same time and month did it descend lower. That was on the morning of the 7th of February, 1855, during a snow-storm, when the temperature indicated was 1° below zero. In like manner, the barometer ranged from 30·358 inches on the morning of the 3d, to 29·099 inches at 4 P. M. on the 18th; showing a difference of height in the column of mercury of 1·259 inches; greater than has been noticed in February, since 1853.

The first three days of the month were very cold; but, after that, the weather moderated, and continued mild until the end of the month.

About 11 P. M. on the night of the 9th, the wind suddenly changed to the north-west, and blew a gale which continued until about 4 P. M. of the 10th. The force of the wind was so great at 7 o'clock on the morning of the 10th, that a new stone retort house at the Point Breeze Gas Works, was blown down, two men being killed by the falling walls. The house was one story high, with a very sharp roof, being 57 feet from the ground to the ridge of the roof. It was 57 feet wide, and 250 feet long, and built of Trenton brown sandstone, the walls being 2 feet thick. The roof was of iron covered with slate, and the greatest care was taken in the construction of the building. A similar building near it was not injured, and other structures, old houses, and frame shops in the immediate neighborhood, were left standing. The retort house destroyed, must have been in the very centre of the tornado.

Snow fell on the 11th, 15th, and 18th days of the month, covering the ground in the aggregate to a depth of about 12 inches.

The coldest day of the month was the 2d, the average temperature of that day being 9·2°.

The warmest day was the 23d; mean temperature, 56·5°.

There were but three days of the month entirely clear or free from

clouds at the hours of observation, and four days on which the sky was entirely covered with clouds.

A Comparison of some of the Meteorological Phenomena of February, 1860, with those of February, 1859, and of the same month for nine years, at Philadelphia.

	Feb. 1860.	Feb. 1859.	Feb. 9 years.
Thermometer.—Highest, . .	70°	63°	70°
" Lowest, . . .	1	18	—1
" Daily oscillation,	17·8	13·2	13·2
" Mean daily range,	8·8	6·3	7·3
" Means at 7 A. M.,	27·24	32·70	28·70
" " 2 P. M.,	38·07	40·64	37·92
" " 9 P. M.,	31·69	35·99	32·93
" " for the month,	32·33	36·43	33·18
Barometer.—Highest, . .	30·358 in.	30·229	30·638
" Lowest, . . .	29·099	29·316	29·065
" Mean daily range, .	·209	·230	·215
" Means at 7 A. M., .	29·970	29·900	29·915
" " 2 P. M., .	29·885	29·864	29·867
" " 9 P. M., .	29·918	29·891	29·896
" " for the month,	29·924	29·885	29·892
Rain and melted snow,	2·724 in.	3·569	2·729
Prevailing winds,	N.62°W·298.	N. 43° W. ·241.	N. 68½°W.·294.

This table shows at a glance the variations of temperature. The *daily oscillation* is seen to be nearly 5° greater than it was last February, and the same amount greater than the average for the last nine years. This daily oscillation is the difference between the highest and lowest degrees of temperature for each day. The average of all these differences for the month gives the number in the table. By the *mean daily range* of the thermometer, is meant the difference between the temperature of one day at the several hours of observation, and that of the day immediately preceding, at the same hours. Thus, if the thermometer at 7 A. M., 2 P. M., and 9 P. M. of the 1st of the month, indicated 11°, 14°, and 7°, and at the same hours on the 2d, 4°, 14½°, and 9°, then the mean daily range for the 2d of the month, would be ascertained by adding the differences at each hour together and dividing the sum by 3, to obtain the average. In this case, it would be $\frac{7+0{\cdot}5+2}{3} = 3{\cdot}17°$. This mean daily range being found for each day, the average for the month is found by adding them together and dividing by the number of days in the month.

It will be noticed in the table that the mean daily range of temperature for February last, is considerably greater than for February, 1859, and a degree and a half greater than the average for February for nine years.

—

WINTER.—As it is frequently interesting and important to compare the seasons of different years with each other, I have prepared the following table, giving the same particulars for the winter as are given

in the above table for the month of February. The winter for meteorological purposes, includes the months of December, January, and February.

A Comparison of the WINTER *of* 1859–60, *with that of* 1858–9, *and of the same season for nine years, at Philadelphia.*

	Winter, 1859–60.	Winter, 1858–9.	Winter, for 9 years.
Thermometer.—Highest,	71°	63°	71°
" Lowest,	1	—2	—5½
" Daily oscillation,	15·60	12·70	12·40
" Mean daily range,	7·90	6·87	6·92
" Means at 7 A. M.,	28·93	32·41	29·29
" " 2 P. M.,	37·64	40·08	37·46
" " 9 P. M.,	32·18	35·60	32·82
" " for the winter,	32·91	36·03	33·19
Barometer.—Highest,	30·399 in.	30·475	30·704
" Lowest,	29·099	29·206	28·941
" Mean daily range,	·189	·214	·212
" Means at 7 A. M.,	29·960	29·973	29·949
" " 2 P. M.,	29·902	29·931	29·908
" " 9 P. M.,	29·929	29·958	29·932
" for the winter,	29·930	29·954	29·930
Rain and melted snow,	9·535 in.	14·258	9·602
Prevailing winds,	N.68°W.289.	N.57°W.268.	N.63°W.304.

*Decimal Coinage in Great Britain.**

The Commissioners appointed to investigate how far it would be practicable and advisable to introduce the principle of decimal division into the coinage of the United Kingdom, have just issued their report, from which we extract the following:—

"The conclusions at which we have jointly arrived are embodied in the following resolutions:—

1. "That the circumstances under which decimal coinage has been introduced in foreign countries, although affording both instruction and warning to us, differ in many important respects from those which exist in this country, and therefore no safe conclusions for our guidance can be drawn from the example, more or less satisfactory, of other countries.

2. "That there appears to be no approach to unanimity of opinion on the question of the introduction of decimal coinage, in the commercial or other classes of the community.

3. "That it is very difficult to come to any useful conclusions as to the merits of the decimal principle in the abstract.

"Distinct and peculiar difficulties attend each separate form in which it has been proposed to introduce the decimal principle into the coinage of the country. A decimal coinage founded on the penny, necessarily ejects the pound sterling; whilst a decimal coinage founded

*From the Lond. Civ. Eng. and Arch. Journal, July, 1859.

on the pound, must involve all the inconveniences attending the abandonment of the penny.

4. "That although many important advantages would attend a decimal coinage founded on the penny, as compared with the pound and mill scheme, yet that a coinage which necessarily involves the disturbance of the pound sterling would, in the present state of public feeling, be unadvisable, and, in fact, impracticable.

5. "That the pound and mill scheme is the only form in which, under the present state of public feeling in this country on the question, the introduction of the decimal principle into our coinage can be contemplated with any reasonable probability of sufficient support.

6. "That as regards paper calculations, there appears to be a preponderance of advantage on the side of decimal coinage; but the extent of the superiority in that respect may be the subject of much difference of opinion.

7. "That as regards the comparative convenience of our present coinage, and of the pound and mill scheme, for the reckonings of the shop and the market, and for mental calculations generally, the superiority rests with the present system, in consequence principally of the more convenient divisibility of 4, 12, and 20, as compared with 10, and the facility for a successive division by 2, that is, for repeated halving, in correspondence with the natural and necessary tendency to this mode of subdividing all material things, and with the prevalence of binary steps in the division of our weights and measures.

8. "That as regards the comparative convenience of the coins provided by the rival systems, the advantage appears to rest with our present coinage.

9. "That the particular form of decimal coinage proposed as the pound and mill scheme cannot be looked upon as a well-assured or demonstrated improvement on our present coinage, but must rather be considered as an experiment of very doubtful result, accompanied beyond all question by many serious transitional difficulties.

10. "That these difficulties are partly of a moral character arising from the violent disturbance of established usages and habits, especially amongst the uneducated classes, which are the least qualified to comprehend, and the least disposed to acquiesce in, such disturbance of their customary course of acting and thinking; and partly of a mechanical character arising from the non-interchangeability of the old and the new coins.

11. "That the advantages in calculation and account-keeping anticipated from a decimal coinage may, to a great extent, be obtained without any disturbance of our present coinage, by a more extensive adoption of the practice now in use at the National Debt Office, and in the principal assurance offices, viz: of reducing money to decimals, performing the required calculations in decimals, and then restoring the result to the present notation.

12. "That duly weighing the foregoing considerations, it does not appear desirable under existing circumstances, while our weights and measures remain as at present, and so long as the principle on which

their simplification ought to be founded is undetermined, to disturb the established habits of the people with regard to the coins now in use, by a partial attempt to introduce any new principle into the coinage alone."

Astronomical Observations.

From the Lond. Artizan, Dec., 1859.

We are glad to hear that the Russian Naval Department has taken up that wonderful invention of Mr. Piazzi Smyth for making astronomical observations on board a rolling ship, and that the Pulkavo astronomers and mechanicians are engaged in manufacturing a large free-revolving apparatus for observing altitudes of stars at night without the aid of the sea-horizon. We should not be less pleased to hear of our own Government taking some advantage of this beautiful and ingenious contrivance.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, March 15, 1860.

John C. Cresson, President, in the chair.
John F. Frazer, Treasurer.
Isaac B. Garrigues, Recording Secretary.
} Present.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, the Society of Arts, and the Institute of Actuaries, London; la Société Industrielle de Mulhouse, France; L. A. Huguet-Latour, Esq., Montreal, Ca.; the Board of Water Commissioners, Detroit, Michigan; the Maryland Institute, Baltimore, Maryland; Prof. A. D. Bache, U. S. Coast Survey, Washington City, D. C.; George Rush Smith, Esq., Senate, Penna. Legislature; Messrs. H. P. M. Birkinbine, William H. Jones, Dr. B. H. Coates, and the Mercantile Library Association, Philadelphia.

Donations to the Cabinets were received from Messrs. Jos. H. Warrington, and Chas. H. Lyons, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of February.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (9) were proposed, and the candidates proposed at the last meeting (6) duly elected.

The Board of Managers reported that they have organized for the present year by electing Mr. William Sellers, Chairman, and Messrs.

Isaac S. Williams and James H. Bryson, Curators, and have appointed the following Standing Committees:

On Publications.	*On Instruction.*	*Managers Sinking Fund and Finance.*
John C. Cresson,	John F. Frazer,	Frederick Fraley,
B. H. Bartol,	Frederick Fraley,	Samuel V. Merrick,
J. Vaughan Merrick,	Isaac B. Garrigues,	Evans Rogers,
Fairman Rogers,	Alan Wood,	John F. Frazer,
Washington Jones.	George Erety.	George Erety.

The Actuary reported that the following Standing Committees have organized by electing their chairmen, and appointing their times of meeting.

Committee.	*Chairman.*	*Time of Meeting.*
On Library,	James H. Cresson,	1st Tuesday evening.
" Exhibitions,	John E. Addicks,	1st Thursday "
" Cabinet Models,	John L. Perkins,	2d Monday "
" Meteorology,	J. A. Kirkpatrick,	3d Friday "
" Meetings,	Washington Jones,	Monday previous to 3d Thursday.

The following resolution was offered and referred to the Committee on Meetings:

Resolved, That meetings of the Institute be held on each Thursday evening of the month, except the third, in order to discuss scientific subjects in an informal manner.

Messrs. Bement & Dougherty presented a model of their improved cotter-driller and key-seat cutter, designed for drilling and mortising gib and key-holes in stubs of connecting rods, and cutting out slots or key-seats of any width, from $\frac{1}{8}$ to $1\frac{1}{2}$ ins., and of lengths from $\frac{1}{2}$ to 30 ins. Two key-seats can be cut at the same time on opposite sides of the one shaft, and perfectly parallel with each other. The quantity of work done is estimated to be *six* times greater than can be done by any other means. Its operating parts are: Two revolving spindles, carrying drills or cutters, moving in carriages which travel longitudinally by means of an attached nut working upon a screw turning in the bed-piece of the machine. The motion of the screw is reversed to give the carriages a return movement, by means of two steel clutches operated by the stops and catches provided for that purpose, and capable of very nice adjustment. A self-feeding arrangement makes the machine entirely automatic. The work is readily put in place, and held either with one center and a pair of self-centering jaws, or by two self-centering jaws.

Messrs. Bement & Dougherty claim an improvement over the English and Scotch cotter drillers, in the adaptation of the screw-traverse motion, thereby obtaining a uniformity of motion not possessed by the latter, which, with a positive reverse motion and universal adjustment in all the parts, make a more satisfactory machine: crank motion combined with elliptic gear wheels being dispensed with. They also claim an adjustable stop-motion as a highly important feature of the machine. Specimens of the work done were exhibited, and bore witness to the accuracy and beauty of the operations of the driller.

Mr. Thomas E. McNeill exhibited and explained his patent "Hot Air Moistening" Register. Immediately above the vents of the ordinary hot air register, a small tank is inserted in the wall, and filled with water. Dipping into this tank and hanging in front of the air vents, is a net-work of candle wick or other suitable material; the net-work becoming saturated with water, the hot air passing between the meshes, becomes moistened before entering the room. A small tank below receives any surplus which may pass over, which is re-absorbed by the net-work when the water in the upper tank is exhausted. The whole is enclosed in an ornamental frame-work projecting about an inch from the wall.

Mr. Jos. H. Warrington exhibited some articles of Japanese manufacture, and explained their make. Amongst them were:—A wooden bowl, lackered with a material of which the composition and mode of application were jealously concealed. Some copper wire, purchased at the price of 9 cents per pound. A rain coat, made of paper, oiled, to prevent the absorption of moisture. The Exhibitor stated that he had worn this coat as a protection against several heavy rain-storms, and that it answered admirably. The smell of the oil used, is not pleasant, but it is not more objectionable than the materials used in making most other water-proof garments.

Mr. Archibald Wilson gave a highly interesting account and illustration of his mode of lighting gas burners by electricity. A chandelier containing fifty-six burners was lighted several times with entire certainty. A full description of the plan and its capabilities will be published in the next number of this *Journal*.

Mr. F. P. Dimpfel exhibited, through the Committee on Meetings, a curious specimen of composition metal, formed of 52 parts copper, 48 parts spelter. Some experiments were tried lately by Mr. Dimpfel, in order to determine the best mixtures for a metal to answer certain purposes, and the sample submitted was a portion which had cooled in the bottom of the crucible. In breaking it up for re-melting, it was found to be perfectly fibrous in structure, except the outer skin, which was, as usual, granular. The fibres are perpendicular to the surface cooled first; they are sonorous, tough, and elastic, and of a golden yellow color, resembling that of spelter solder, being nearly of the same composition. The endeavor was made to get castings having the same structure, for pump rods; but the trial was not successful, the fibres being transverse instead of longitudinal, probably owing to a disposition to arrange themselves perpendicularly to the cooling surfaces. Experiments are still making under varied conditions, to produce castings with the fibres in a direction coinciding with that of the rupturing forces, but thus far without success.

Mr. D. P. Deiterich sent for the inspection of the members, a Vulcanite Emery-wheel, for cutting, grinding, or polishing. It is composed of prepared india rubber, combined with emery. The latter material is made of any grade required for cutting or for polishing. The vulcanite can be spread in thin sheets on leather, cloth, or paper; or made in solid plates. When used with oil, a dead finish results; when with water, a grindstone finish; or, when dry, a bright polish.

The wheels can be turned off in a lathe running slowly; thus, any desired shape can be given to the grinding surfaces, or they can be trued up, should the surface become uneven or glazed. Wheels of from 12 ins. diameter 2 ins. face, to 1½ ins. diameter ¼-in. face, are made, with intermediate sizes, so that any kind of work, either plain or moulded, can be surfaced by them.

The Committee on Meetings presented to the notice of the members a Hydraulic Instrument, patented by Mr. J. E. Wootten, and designed to supersede the use of the ordinary crowbar, as applied to moving locomotive engines or railroad cars by hand power, an operation technically known as *pinching*.

The instrument is compact, simple in its arrangement, and light, its weight being but 13 lbs.

By its use, the power applied to the lever is multiplied a hundred times, and the accumulated power is applied directly against the periphery of one of the wheels of the engine or car to be moved.

BIBLIOGRAPHICAL NOTICE.

Engineering Precedents, Vol. II, 8 vo. pp. 231. By B. F. Isherwood, U. S. N.: Bailliére Brothers, 440 Broadway, N. Y.

The above is the second of the series, the first volume of which has previously been noticed in this *Journal*. Its contents are more varied and numerous; and, in a practical point of view, more valuable to the engineer: embracing the records of experiments to determine the relative efficiency of certain coals, the economic effect due to the expansion of steam, the value of Prosser's and of Ellis' boilers, and the comparative advantages of Horizontal and Vertical Tubular Boilers, together with synopses of the performance of the U. S. Steamers *Niagara* and *Massachusetts*.

The work before us exhibits in a remarkable degree the care and patient research of its author.

The limits of a brief notice on such a work, forbid our entering critically upon all the subjects so interesting to the engineer which have been treated in it. We shall notice only a few of the more striking. The experiments on coals embraced Blackheath anthracite, Trevorton and Cumberland semi-bituminous, burned with and without perforated fire doors; and although from the type of boiler, size of the engine, and other peculiar circumstances, they afford no indication of the *absolute* values of either of the combustibles named; yet there seems no reason to discredit the accuracy of a comparison based upon the results observed; since in all the experiments these circumstances were the same, and the duration long enough to eliminate errors of observation.

The general comparison of evaporative efficiency was found to be as follows:—

	By Weight.	By Bulk.
Blackheath,	1·00	1·00
Trevorton,	1·21	1·07
Cumberland,	1·24	1·20

With air holes in the furnace doors, these results were increased from $2\frac{3}{4}$ to $5\frac{1}{4}$ per cent.

The comparison between the "Horizontal Fire Tube," and "Vertical Water Tube," boilers of the U. S. Steamer *San Jacinto*, has already been published in this *Journal*. It indicates an economical superiority in the latter type under the conditions of the experiments made, when the combustion was necessarily slow, the vessel being moored at the dock. The important question remaining to be decided by accurate experiment is, to what extent, if any, this superiority may be affected by the rapid evaporation required in the boilers of merchant steamers?

We regard the account of experiments made with the Smithery Engine at the New York yard with a view to determine the practical advantages of working steam expansively, and the deductions drawn therefrom, (to whatever extent they may be sound,) as by far the most important part of the book. The author, as we have said, is careful and pains-taking in making and observing his trials; he is also bold in enunciating his ideas and deductions, although they may conflict with theories generally received. It is a little unfortunate that the work done by the engine on which the trials were made, was disproportionately small for it; and although the disadvantages attending this fact were more damaging to the economy of "following long" than of cutting off short, yet, from this cause cavilers may be disposed to dispute Mr. Isherwood's conclusions. It cannot, however, be denied that, in some important particulars, those conclusions are well founded. He shows—

1st. That the economic gain from expansion is very much less than theory indicates.

2d. That leakage of valves plays an important part in the economy of the steam engine when expansion is used; increasing the apparent effect produced by it, and assimilating, to a considerable degree, "throttling" and "cutting off" steam.

The reasons given for assertions so contrary to the ideas generally held by scientific and even by many practical engineers, are cogently stated and deserve an attentive consideration. In the first place, attention is drawn to the losses which occur before steam is admitted into the cylinder, and which therefore are to be subtracted from the entire evaporative efficiency of the combustible before comparisons can be entered into of the effect of various degrees of expansion; these may reduce the theoretical value of the fuel nearly one-half in marine engines; hence any gain from expansion must be referred to this diminished principle; secondly, the losses of steam required to fill clearance and ports relatively increase with greater expansions, because they remain the same while the proportion of the cylinder to be filled is reduced; thirdly, the back pressure, amounting to about 5 pounds in condensing, and at least 15 lbs. in non-condensing engines, is a constant quantity for any point of cutting off; fourthly, the friction of engine, or power required to work it at a proper velocity, is a constant quantity for all degrees of expansion; fifthly, there is a certain condensation *due to the expansion itself* and irrespective of all other considera-

tions, which annihilates a portion of the steam, and this evil becomes greater, the farther expansion is carried out. All these causes combined reduce, to an enormous amount, the theoretical gain due to expansion; and we advise all advocates of that principle to study our author's volume. As a necessary result of his deductions, Mr. Isherwood is no friend to "Patent cut-offs."

As we do not remember to have seen elsewhere a distinct statement of the doctrine above alluded to, that condensation attends expansion as a condition of the case, we shall quote it for the benefit of our readers in the author's own words, in order that this very important subject should receive a thorough "ventilation;" reserving to a future opportunity any comments we may have to make upon it.

"With steam of any given tension, the particles of water are at a certain distance apart and are kept at that distance by the repulsive effect of a certain quantity of heat to which the term "latent" is applied. The effect of this heat being expended entirely in keeping the particles asunder, it is balanced by the mechanical work equal to resisting their approach in consequence of their attraction for each other, hence it cannot be sensible to the thermometer, for it cannot be expended two ways, one in keeping the particles of water apart, and the other in imparting temperature to foreign bodies, as the thermometer. By cutting off the steam from any further accession of heat and simply expanding it, the particles are removed to a further distance apart, and to keep them at this greater distance more latent heat is required; but the supply of heat from fuel being shut off, this additional amount of latent heat cannot be obtained except by the condensation of enough of the steam to liberate so much heat as will maintain the balance of the steam in the form of steam. In other words, the latent heat that was sufficient to keep a given weight of steam of a given tension in the form of steam, being insufficient to maintain that same weight in the form of steam when its particles are removed further apart by expansion, has concentrated its action upon such portion of the steam as it could maintain in that form, and the other portion by this abandonment returns to its original state of water. And here we have the cause of the condensation of steam by expansion *per se*.

"What is called the sensible heat of steam is the heat above what is necessary for keeping the particles asunder in the form of steam, and the use of sensible heat is merely to equilibrate the pressure under which the steam is generated, and will vary with the pressure. If steam were generated *in vacuo* and free from influence from outside temperature surrounding the vessel, it would have no sensible temperature and the total heat would be all latent heat, for on that alone depends the characteristic difference between steam and water, namely, elasticity."

The mechanical execution of the whole work is good, and we feel assured that the labors of its author in the cause of engineering will be the better appreciated as they are more fully known. M.

Abstract of Meteorological Observations for January, 1860; made in Philadelphia, Adams, and Somerset Counties,

Abstract of Meteorological Observations for January, 1860; made in Philadelphia, Adams, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.

1860.	PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet. Prof. J. A. KIRKPATRICK, Observer.									GETTYSBURG, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Height 624 feet. Prof. M. JACOBS, Obs.						SOMERSET, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. GEO. MOWRY, Observer.							
	Barometer.		Thermometer.			Force of vapor.	Relative humidity.	Rain and Snow.	Prevail'g winds.	Barometer.		Thermom.		Rain and Snow.	Prevail'g. winds	Barometer.		Thermom.		Force of vapor.	Relative humidity.	Rain and Snow.	Prevail'g winds.
Jan.	Mean.	Mean daily range.	Mean.	Daily oscillation	Mean daily range.	2 P.M.	2 P.M.			Mean.	Mean daily range.	Mean.	Mean daily range.			Mean.	Mean daily range.	Mean.	Mean daily range.				
	Inch.	Inch.	°	°	°	Inch.	Per ct.	Inches.	Direc.	Inch.	Inch.	°	°	Inch.	Direc.	Inch.	Inch.	°	°	Inch.	Per ct.	Inch.	Direc.
☽ 1	30·115	·148	10·3	11	11·8	·055	71		N N W.	29·777	·162	3·7	13.3		N W.	27·764	·111	1·0	7·0	·043	59		W.
2	30·245	·130	11·0	13	1·3	·058	65		N W.	29·963	·126	2·3	2·0		N W.	27·942	·178	5·3	4·3	·067	81		W.
3	30·216	·079	16·0	15	5·0	·067	62		S W.	29·826	·117	7·7	8·7		S W.	27·853	·148	18·7	13·3	·140	88		W.
4	30·011	·205	25·8	9	10·5	·129	88	0·185	S W.	29·640	·186	23·3	9·7		(var.)	27·773	·156	21·7	11·0	·153	88	0·316	W.
5	30·337	·326	15·5	18	10·3	,072	63		N W.	30·027	·389	9·0	15·7		N W.	28·011	·238	10·0	11·7	·134	87		WNW
6	30·287	·121	19·2	16	3·7	·085	67		S W.	29·905	·153	6·3	6·0		(var.)	27·855	·186	21·0	11·0	·175	89		S W.
7	29·924	·364	35·3	22	16·2	·185	81	0·718	N E.	29·508	·397	28·3	22·0	0·850	S W.	27·518	·338	40·0	19·0	·248	100	0·326	S.
○ 8	29·844	·139	35·7	9	5·0	·207	93		N E.	29·411	·176	32·3	6·0		S S W.	27·571	·112	39·3	3·3	·218	75		W.
9	30·063	·217	40·3	20	6·0	·176	55		N W.	29·686	·280	32·7	3·7		S S W.	27·733	·162	37·0	4·3	·211	72		S.
10	30·014	·046	35·7	9	7·0	·198	90		S W.	29·646	·038	35·7	3·7		S.	27·701	·032	47·7	10·7	·282	67		S W.
11	29·882	·132	42·5	17	6·8	·308	89		S W.	29·443	·208	37·3	5·0	0·640	S.	27·600	·129	42·0	9·0	·311	92	0·514	(var.)
12	30·035	·153	33·0	12	8·2	·141	69	0·663	N W	29·672	·232	31·3	6·0		(var.)	27·757	·153	27·3	14·7	·144	63		(var.)
13	30·203	·168	31·2	6	2·2	·119	61		W N W	29·844	·172	28·3	4·3	0·880	N E.	27·836	·079	24·7	8·0	·168	94	0·795	S.
14	29·824	·378	31·8	5	2·0	·162	89	1·219	N.	29·401	·443	32·7	4·3		S S W.	27·463	·373	35·3	10·7	·220	100		S.
☾ 15	29·693	·196	34·3	9	2·5	·188	85		S W.	29·254	·170	35·7	3·0		(var.)	27·400	·099	31·3	4·0	·168	89		W.
16	29·701	·057	40·7	19	6·3	·220	63		S W.	29·268	·046	38·0	3·0		(var.)	27·442	·042	37·7	6·3	·202	72		W.
17	29.644	·094	36·8	9	5·2	·173	69		N W.	29·191	·078	33·3	8·7	0·085	N W.	27·376	·066	31·3	6·3	·142	69		W.
18	29.772	·131	34·5	11	2·3	·108	45		(var.)	29·343	·153	31·7	4·3		S S W.	27·410	·049	27·0	5·0	·161	89		(var.)
19	29·851	·119	32·7	10	4·5	·082	42		(var.)	29·455	·112	28·7	3·0		N W.	27·604	·194	25·7	2·0	·147	78		W.
20	29·891	·086	39·3	20	8·7	·153	47		S W.	29·491	·084	34·0	5·3		S.	27·647	·043	38·7	13·0	·238	77		S W.
21	29·761	·131	46·3	26	7·0	·199	41		S S W.	29·337	·154	47·0	13·0		S W.	27·552	·094	46·0	7·3	269	67		W.
● 22	29·783	·034	47·5	16	4·8	·195	46		W N W	29·410	·073	42·7	3·7		(var.)	27 602	·071	39·0	7·0	·212	63		W.
23	30·065	·283	39·2	15	8·3	·126	44		W.	29·716	·306	35·7	7·0		N.	27·847	·245	33·3	5·7	·195	68		(var.)
24	30·024	·129	41·7	20	4·5	·151	45		S W.	29·584	·156	38·7	6·3		S.	27·725	·122	44·7	11·3	·275	65		S W.
25	29·788	·237	48·3	15	7·7	·112	24		W.	29·400	·214	47·3	12 7		(var.)	27·669	·103	41·0	17·0	·204	68	0·026	W N W
26	29·920	·144	35·2	15	13·2	·094	38	0·138	(var.)	29·454	·149	29·7	17·7	0·280	S W.	27·589	·159	28·0	13·0	·167	100	0·476	(var.)
27	29·835	·086	29·0	9	6·5	·105	62		N W.	29·423	·098	26·7	3·7		N W.	27·571	·089	26·7	5·3	·153	88		W.
28	29·772	·063	31·7	16	4.7	·127	60		S S W.	29·355	·106	26·0	6·7		S S W.	27·453	·184	25·0	1·3	·175	94	0·226	W.
29	30·043	·272	31·5	14	1·2	·108	50		S W.	29·615	·260	26·7	3·3		S.	27·649	·259	28·3	14·7	·124	40		S W.
30	29·805	·239	44·3	24	12·8	·191	47		S S W.	29·385	·230	40·3	13·7		W.	27·530	·128	39·7	14·0	·150	52		W.
☽ 31	29·828	·042	39·3	28	6·3	·163	38	0·428	W.	29·442	·057	34·3	8·0	0·400	(var.)	27·594	·064	29·7	10·7	·211	73		(var.)
Means	29·941	·159	33·4	15	6·5	·144	61	3·351	s89°w.	29·542	·178	29·3	7·5	3·135	s77°w	27·646	·142	30·5	9·1	·184	78	2·679	s78°w